

USAID DCHA ENVIRONMENTAL THRESHOLD DECISION FOR NIGER AGRICULTURAL CROP, LIVESTOCK, AND COMMODITY STORAGE PERSUAP

Awardee: CRS (PASAM-TAI), Mercy Corps (Sawki), Save the Children International

(LAHIA)

Food for Peace - Bureau for Democracy, Conflict and Humanitarian Operational Unit:

Assistance (DCHA/FFP)

PASAM-TAI, Sawki, LAHIA **Program Title:**

Country/Region: Niger

Life of Grant: FY12-FY17

LOA Funding: \$39.7 Million, \$29.99 Million, and \$34.49 Million

PERSUAP Prepared by: Sun Mountain International **Date**: 6 June 2014

ENVIRONMENTAL ACTION RECOMMENDED:	
Categorical Exclusion: X	Negative Determination w/ Conditions: X
Positive Determination:	Deferral:
Environmental Threshold Decision (ETD):	Approval with Conditions

<u>Summary of Findings</u>
The DCHA BEO would like to commend Catholic Relief Services (CRS), Mercy Corps (MC), Save the Children International (SCI), and Sun Mountain International (SMTN), for their excellent work in preparation of this PERSUAP for DCHA FFP Niger Agricultural Crop, Livestock, and Commodity Storage activities.

Following initial DCHA BEO review, seven (7) issues were determined to require additional attention. These issues were:

- 1. Verification of authenticity of example set of 14 pesticide products;
- Pesticides recommended in the PERSUAP which are not approved in Niger; 2.
- Neonicotinoid insecticides to be applied only by qualified phyto-sanitary brigades; 3.
- Restricted use pesticides (RUPs) to be applied only by qualified phyto-sanitary brigades or 4. by Ministry of Livestock and Animal Husbandry agents:
- 5. Copper oxychloride in USEPA Acute Toxicity Category I:
- Miscellaneous edits to the PERSUAP; and, 6.
- 7. Translation of relevant portions of the PERSUAP into French.



As PERSUAP preparer, SMTN worked with CRS, MC, and SCI to address these issues and resubmit the PERSUAP. Following review of this response, the PERSUAP is now ready for DCHA BEO clearance subject to conditions as established below.

USAID Bureau Environmental Officer Approval:

This Environmental Threshold Decision (ETD) is to inform that the Niger Agricultural Crop, Livestock, and Commodity Storage PERSUAP (attached to this document) has received approval, subject to conditions, by the DCHA Bureau Environmental Officer (BEO), on May 8, 2015. The Niger Agricultural Crop, Livestock, and Commodity Storage PERSUAP meets the minimum USAID 22 CFR 216 requirements for the ETD.

However, the BEO has identified three (3) conditions remaining from the initial 7 issues; these conditions are summarized below, for the attention of CRS, Mercy Corps (MC), and Save the Children International (SCI).

<u>Condition 1</u>: Conduct additional follow up research regarding contact information for regional/national pesticide distributors by contacting representatives from Agrimex-Niger and ALM International to determine the composition and validity of the pesticide A.I.s (bacillus thuringiensis, chloranthrailiprole, methoxy-fenozide, tebufenozide, mancozeb, and metalaxyl) in Niger.

<u>Condition 2:</u> Add a footnote to Table B of the Executive Summary, as proposed in the tracked changes in the attached PERSUAP document, stating, "Only products that are registered and approved for use in Niger by the Sahelian Pesticide Committee (CSP) of the CILSS, at the time of the intervention are permitted for program support by this PERSUAP. As of November 2014, pesticide products containing the Als listed in Table B cannot be supported.

<u>Condition 3:</u> Add restrictions in the PERSUAP that only non-RUP formulations be used for the A.I.s zeta cypermethrin and beta cypermethrin.

<u>Issue 1</u>: CRS, MC and SCI will provide the contact information (i.e. email address, phone number, title) for the regional/national pesticide distributor(s), for the highlighted fourteen (14) pesticide products in the Table 1.

DCHA BEO/GEMS review notes that the contact information was provided for some vendors. The contact information for Agrimex-Niger appears to be useful though a specific contact person is not mentioned. Similarly, the contact for ALM international looks useful as it is a local Senegal phone number but no contact person was listed. The contact info for the remainder of the products does not appear to be useful to tracking the pesticides. It contains European websites or generic shopping websites like Alibaba, and phone numbers which are generic and unlikely to provide specific information for the distribution of these pesticides in Niger.

<u>Condition 1</u>: Conduct additional follow up research regarding contact information for regional/national pesticide distributors by contacting representatives from Agrimex-Niger and ALM International to determine the composition and validity of the pesticide A.I.s (bacillus thuringiensis, chloranthrailiprole, methoxy-fenozide, tebufenozide, mancozeb, and metalaxyl) in Niger.



<u>Issue 2</u>: USAID would like approval to speak directly to the PERSUAP author regarding pesticides not approved by the Government of Niger (GON), for efficiency sake, keeping CRS and AOR well notified.

DCHA BEO/GEMS received responses from the pesticide author via email. The rationale of the author to encourage registration of certain pesticide A.I.s, including those listed in Table B in the executive summary appears sound; however, it is unlikely that representatives from the GON will follow the PERSUAPs suggestions to promote registration of these pesticide A.I.s.

<u>Condition 2:</u> Add a footnote to Table B of the Executive Summary, as proposed in the tracked changes in the attached PERSUAP document, stating, "Only products that are registered and approved for use in Niger by the Sahelian Pesticide Committee (CSP) of the CILSS, at the time of the intervention are permitted for program support by this PERSUAP. As of November 2014, pesticide products containing the Als listed in Table B cannot be supported.

<u>Issue 3</u>: USAID requires consultation with the PERSUAP author to confirm that the GON phytosanitary brigades and Ministry of Livestock animal husbandry agents are qualified to apply RUPs.

DCHA BEO technical review received responses from the author, via email as noted above. It appears that the phytosanitary brigades are qualified to apply RUP in a limited way. However, the PERSUAP authors could not confirm that they are properly trained, as no training materials were provided by the Ministry or the brigades. The PERSUAP authors maintain that the restrictions included in the PERSUAP will properly limit RUP application to safe use. The restrictions for the potential RUPs, zeta cypermethrin and beta cypermethrin, were not noted in the PERSUAP

<u>Condition 3:</u> Add restrictions in the PERSUAP that only non-RUP formulations be used for the A.I.s zeta cypermethrin and beta cypermethrin.



ISSUES IDENTIFIED DURING INITIAL DCHA BEO REVIEW

<u>Issue 1:</u> Verification of authenticity of example set of 14 pesticide products based on additional the information on chemical composition and formulation of pesticides.

<u>Discussion</u>: The PERSUAP author, Sun Mountain International, completed the conventional methodology to collect data on pesticide use and management in Niger. In order to augment the conventional means, as described below, it is recommended that additional data from pesticide distributors at the national and regional level be collected and reviewed to verify the authenticity of the pesticides used in Niger.

Methodology:

The author of the PERSUAP, Sun Mountain International, worked with the implementing partners during development of the PERSUAP to visit pesticide vendors, farmers and stakeholders to understand pesticide management in the Niger under the three USAID programs.

According to Section 1.2 of the PERSUAP, the methodology for development of the PERSUAP included meetings with "...key regulators of the agricultural inputs sector, public institutions involved in providing extension services to farmers, and private sector actors and non-governmental agencies in the pest management industry," and meetings with "farmers and producer groups to gather information on their knowledge and practices in pest management and pesticide safety." Field work included two separate efforts:

- The PERSUAP field work for CRS PASAM-TAI program was conducted in Niger from January 20th 30th, 2014. The assessment team collected information in Maradi and Matameye from January 20th 25th and in Niamey from January 27th 30th.
- The PERSUAP field work for the MC Sawki program and the SCI was conducted in Niger from March 26th - April 8th, 2014. The assessment team collected information in Niamey on March 26th and in Maradi, Aguie, and Zinder from March 27th - April 8th, 2014.

"In addition to the field work, the assessment team carried out a desk-review to determine toxicological profiles for each chemical provided in the PER 12-factor analysis, as well as non-chemical pest control measures that complement the recommended pesticide as part of an Integrated Pest Management framework.

"SMTN staff reviewed the Sahliene Pesticide Comittees' and US Environmental Protection Agency's registration systems for pesticides, as well as compared findings in other PERSUAPs, such as the recently cleared PERSUAP Covering CORAF/WECARD coordinated Feed the Future (FTF) Activities implemented by member National Agricultural Research Systems (NARS) in West Africa."

Conventional Verification of Pesticide Authenticity:

We expect that during their site visits to small businesses selling pesticides, agro-input dealers, in the program areas, the Sun Mountain assessment teams completed a limited review of pesticides labels.

As noted in Section 2.3, on page 23 of the PERSUAP, "many illegal, fake, and non-registered brands of pesticides enter Niger from neighboring countries or are produced within Niger,



according to stakeholder reports. A recent study by the extension services found that from a total of 149 pesticide brands available in the market, only 13% were registered in Niger. Of the others, 40% were from Nigeria, 35 % from China, 13% from Ghana, 8% from India, and 4% from other countries."

In order to obtain additional details on the manufacturer and chemical composition of each pesticide evaluated in the PERSUAP, we would like the contact information of the 14 pesticide products. GEMS selected a random sample of 14 pesticide products from the list of recommended pesticides in the PERSUAP as shown in Table 1.

<u>Condition 1</u>: CRS, MC and SCI will provide the contact information (i.e. email address, phone number, title) for the regional/national distributor (s), for the highlighted fourteen (14) pesticide products in the attached Table 1. Upon review of the additional data collected and analyzed by GEMS, the list of approved pesticides will be amended if necessary.

<u>Issue 2:</u> Pesticides Recommended in the PERSUAP which are not approved in Niger.

<u>Discussion 2</u>: In many cases, PERSUAPs do NOT include pesticides in an approved list that have NOT been registered in the host country. We are currently reviewing the subset of recommended pesticides that are not registered/approved in Niger to determine which have significant advantages (for the FFP program and implementing partners) over the registered pesticides.

As noted in Section 3.3,a., on page 35, of the PERSUAP, "there are a number of pesticides approved by this PERSUAP that are not currently registered with the CSP or do not have any products that are currently approved.

For these pesticides to be eligible for use in practice by the programs, the programs should work to have these Als or products approved by the CSP. The registration process is structurally lengthy, and without guarantee of approval, but diversification of the types of products available in Niger would have broad benefits for program agricultural activities and safer pesticide use in the agricultural sector in general.

These pesticides, which are generally newer and more specifically targeted, are encouraged because they may fit a role that reduces the overuse and overreliance on a small number of broad-spectrum pesticides, which is likely to result in the development of pest resistance to pesticides. The programs are advised to lobby and/or collaborate with agrochemical companies and suppliers to homologate products with safer, more specific-use Als."

<u>Condition 2</u>: It is recommended that only the unregistered pesticides with significant advantages remain on the list of approved pesticides; GEMS has currently conducting a preliminary review of these pesticides.

Issue 3: Neonicotinoid insecticides to be applied only by qualified phyto-sanitary brigades.



<u>Discussion3</u>: Neonicotinoid insecticides like Imidacloprid are suspected of being one of the factors causing colony collapse disorder in bee populations. As a result, they are not typically recommended for general use and are typically restricted to seed treatment; however, given that their application will only be performed by GoN trained and equipped phyto-sanitary brigades, their approval seems acceptable in this context.

<u>Condition 3</u>: USAID requests that CRS, Mercy Corp and Save the Children highlight these restrictions (i.e. application only by GoN phyto-sanitary brigades) throughout the PERSUAP in appropriate tables and text.

<u>Issue 4</u>: Restricted use pesticides (RUPs) to be applied only by qualified phyto-sanitary brigades or by Ministry of Livestock and Animal Husbandry agents

<u>Discussion 4:</u> Because they are designated by the EPA as restricted use pesticides (RUPs), the fumigants/insecticides, **aluminum phosphide and chlorpyriphos-ethyl**, used for commodity protection are normally not approved for use in these PERSUAPs; however, given that only the GoN phyto-sanitary brigades and approved fumigation service providers will be performing the application, their approval seems acceptable in this context. Similarly, for the RUP **acaracide zeta-cypermethrin**, its use is approved as long as it is applied only by Ministry of Livestock and Animal Husbandry agents.

Condition 4: No action required.

Issue 5: Copper oxychloride in USEPA Acute Toxicity Category I

<u>Discussion 5:</u> Copper oxychloride has been included in USEPA Acute Toxicity Category I for irreversible eye damage, so we would remove it from the list of approved pesticides. If there are other copper oxychlorides within Category II, III or IV, then they would be acceptable alternatives. Another alternative would be the use of copper sulfate pentahydrate to replace copper oxychloride.

<u>Condition 5</u>: USAID requests that CRS, MC and SCI remove copper oxychloride from list of approved pesticides. Potentially replace with less toxic copper oxychlorides or copper sulfate pentahydrate.

Issue 6: Miscellaneous edits to the PERSUAP.

<u>Discussion 6:</u> Tables 4 and 5, which present information on pesticides approved for rain-fed, staple, or cash crops and approved for other vegetable production, appear to be out of place in the document. Cadmus has also made additional minor edits as shown in the attached tracked changes version of the PERSUAP

<u>Condition 6</u>: USAID requests that CRS, MC and SCI move Tables 4 and 5 from the discussion on PPE in the evaluation of factor "d" in Section 3.3, d., on pages 39 through 40, to another, more



relevant section of the PERSUAP, and that CRS, MC, and SCI review and accept the minor edits in the PERSUAP.

Issue 7: Translation of PERSUAP into French.

<u>Discussion 7:</u> As best practice, we recommend that a summary of the PERSUAP be translated into French including the main points of the SUAP, the list of approved pesticides and relevant tables.

<u>Condition 7</u>: USAID requests that CRS, MC and SCI translate the relevant portions of the PERSUAP.



DCN: DCHA FFP NIGER PERSUAP 2012-17

Initial Environmental Examination (IEE) Amendment/Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) Facesheet USAID / DCHA / Food for Peace (FFP)

Activity/Project Data:

Activity/Project Title: PASA	M-TAI, SAWK	I, LA	HIA	
Contract/Award Name(s) &N	umber(s) (if know	wn): A	ID-FFP-A-12-00005, A	AID-FFP-A-12-00012, and
AID-FFP-A-12-00010				
Geographic Location (Countr	y(ies)/ Region/G	lobal):	Niger/Sahel	
✓ Amendment✓ Supplemental IEE	DCN and date of	of Orig	inal RCE/IEE/EA: Jan	uary 2012
Supplemental IEE	DCN and ECD	link(s)	of Amendment(s) or s	upplemental IEE: N/A
Annual Funding Amount: \$8	million		of Project Amount (if m 9 Million, and \$34.49 I	nulti-year): \$39.7 Million, Million
Life of Project: FY12-FY17			IEE Expiration Date:	30 September 2017
IEE Prepared By: Sun Mounta	ain International	with	Date Prepared: 6 June	2014
support from CRS, MC, and S	SCI		Date Revised before A	Approval: 30 March 2015
ECD Web Link: N/A				
Recommended Threshold D ☐ Categorical Exclusion ☐ Negative Determination ☐ Positive Determination ☐ Deferral			vith Conditions	
Implementing Partners (gover All DFAP Partners in Niger (ICRISAT, GRET and GoN				ef Services), CADEV,
Sector Types/Program Elem	nents: (check all	that a	pply)	
Agriculture:				
Aquaculture		h Value	e Ag	
Intensification	– <i>e</i>			
Market Access	∐Pest	1cides		☑Livestock☐Biosafety for GMO
Climate Change:				
GCC/Adaption		C/Mitig	ation	
Construction/Infrastructure:	_			_
Bridges	∐Can			Dams
Extractive Industries		en Build nerator	ding	Healthcare Facilities
☐Housing ☐Infrastructure	_	nerator Build		☐ Industrial Facilities ☐ Operations and
Oversight		elines		Management
Railroads		abilitati	ion	Ports

☐Roads ☐Transmission Lines	☐Schools ☐Wastewater Treatment Plant	⊠Renovation ☐ Telecommunications	
Economic Growth:	wastewater freatment rain	Telecommunications	
Cleaner Production □Eco/Sustainable Tourism □Microfinance □Trade	☑ Competitiveness☑ Financial Intermediation☑ Public Private Partnerships	☐ Development Credit Authority (DCA) ☐ Micro and Small Enterprises ☐ Technology	
⊠ Education			
Energy: Coal Efficiency Oil/Diesel Other:	☐Distribution ☐Hydro ☐Solar	□EC-LEDS □LNG □Wind	
☐ GDA			
Governance: ☐Democracy, Human Rights, and Gov. ☐Rule of Law	□ Land Tenure and Property Rights	□Media	
Health: ☐HIV/AIDS ☐ Hygiene ☐Medical Waste Management ☐Vector Management	☐ Health Education and Training ☐ MCH ☐ Nutrition (includes small-scale gardening)	☐ Health Systems Strengthening (commodities) ☐ Malaria ☐ TB/MDR	
Natural Resources Management:			
☐ Biodiversity/Protected / Protected Areas ☐ Fisheries ☐ Payment of Ecosystem Services ☐ Resource Governance	☐CBNRM ☐Forestry ☐Pollution Prevention ☐Sustainable Landscapes ☐Invasive Species		
Relief to Development:	_		
☐Disaster Response	Disaster Risk Reduction & Prevention	Humanitarian Response	
Waste Management:			
Incineration	Landfill	Recycling	
Water: Wastewater Collection Water Distribution	☐Wastewater Treatment ☐Water Supply	☐ Wastewater Treatment Operations ☐ Water Treatment/Sanitation	
Brief Needs Statement:			
In Niger, pests cause damage to stored warehouse commodities, livestock, and agricultural rain-fed, staple, and cash crops. For this reason, USAID/Niger Title II programs include a number of activities that require effective management of pests to achieve their objectives. Pests include arthropods and vertebrates, fungal and viral diseases, and nematodes.			

SUMMARY OF FINDINGS:

1. Background and Project/Activity Description

a. Purpose and Scope

In compliance with USAID's Pesticide Procedures (22 CFR 216.3(b)), this 2014 Niger Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP):

- Establishes the set of pesticides for which support is authorized for USAID/Niger Agriculture Sector activities.
- Establishes the requirements for support for these pesticides to assure that pesticide use/support (1) embodies the principles of safer pesticide use and, (2) per USAID policy, is fully within an Integrated Pest Management (IPM) framework.

This PERSUAP covers the following FFP Niger program activities that currently, or will in the future, involve promotion of improved pest management best practices involving pesticides for:

- Rain-fed, staple, and cash crop improved production;
- Vegetable and fodder production improvement, IPM and pesticide safer use training;
- Livestock health and sanitation; and
- Warehouse commodity protection.

The PERSUAP identifies the active ingredients (AIs) that can be used by the FFP Niger program activities. It also specifies for which crops and activities those AIs can be used. AIs not approved by this PERSUAP cannot be procured, used, or promoted by the FFP Niger program, unless there is an approved amendment to this PERSUAP.

b. Background: Development of this PERSUAP

CRS initially contracted Sun Mountain International of Quito, Ecuador, to develop this "Stored Commodity, Livestock, and Agricultural Crop PERSUAP" for their "PASAM-TAI" project in Niger. While the CRS PERSUAP was under development, it was decided that the PERSUAP should also cover the two additional Title II Development Food Assistance Programs (DFAPs) in Niger, due to their shared requirement for a PERSUAP to cover Title II stored warehouse commodity fumigation and agricultural activities that support targeted pesticide uses. Thus, the "Sawki" program implemented by Mercy Corps Niger and the "LAHIA" program implemented by Save the Children International were included in this PERSUAP analysis to form an umbrella report for the three programs.

c. Key baseline environmental information

Chronic and acute food insecurity and malnutrition continue to impact the livelihoods of the most vulnerable Nigeriens. Roughly four in five Nigeriens are fed by subsistence farming in a region experiencing great challenges to subsistence farming. Widespread millet-crop failures in 2011 and the compounding effects of previous droughts, locust attacks, or weevil infestations in stored food have led to a dangerous reduction in food for between 25-50% of Niger's agro-pastoralists.

d. Locations affected

The Development Food Assistance Programs' technical interventions in agriculture present an integrated approach to reducing chronic and acute food insecurity and malnutrition, improving livelihoods, and protecting against shocks in two regions of Niger: 1) Maradi and 2) Zinder.

Specifically for warehouse commodity protection, fumigation will occur at the following sites for the different programs.

Catholic Relief Services:

Warehouse	City name	HQ	ROAD	NORTH LAT	EAST LONG
Warehouse 1	Maradi	Ali Dan sofo	Mohamed vI	13.491.84	7.125.43
Warehouse 2	Maradi	Zarya I	Rue Général Ali Saibou	13.51.167	7.108.22

Mercy Corps:

Warehouse	City name	HQ	ROAD	NORTH LAT	EAST LONG
Warehouse 1	Maradi	Bourja	Route Dan Issa	13° 28' 32.6''	7º 06' 46,4''
Warehouse 2	Zinder	Ja-guindi	Route SONIDEP	13° 49' 47,8''	8° 06' 46,4''
Warehouse 3	Zinder	Ja-guindi	Route SONIDEP	13° 49' 47,8''	8° 06' 46,4''

Save the Children:

QUARTIER ZARIA, Coté du Chateau 3 Avenue general Ali Chaibou, Rue ZR2-R088, Maradi

2. Threshold Determinations:

The procurement, use, and promotion of pesticides by the FFP Niger programs was determined to be Negative Determination with Conditions by USAID, pursuant to 22 CFR 216. This Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP) is in response to this threshold determination and is in compliance with USAID's Pesticide Procedures, 216.3(b).

3. Approved Active Ingredients:

Products approved by the Sahelien Pesticide Committee (CSP) with the following active ingredients (AIs) are permitted for procurement, use, and promotion upon USAID approval of this PERSUAP. Table A, see next page, represents the current list of AIs that have registered products by the CSP (see Annex 5 for specific CSP authorized products). This list is subject to change. FFP Niger programs should always ensure that pesticides to be procured, used, or promoted have AIs that are approved in this PERSUAP and are products that are registered and authorized for use by the CSP.

Table A: Approved AIs with registered products by the CSP as of November 2014.

Approved Pesticides ¹	
Insecticides/Acaricides	Fungicides/Bactericides
Acetamiprid (May not be used during flowering on	Azoxystrobin
crops pollinated by honeybees)	Difenoconazole (Seed treatment only)
Azadirachtin (Neem oil; also a fungicide)	Mancozeb
Bacillus thuringiensis	Mefenoxam (Metalaxyl-M)
Chloranthraniliprole	Thiram
Flubendiamide	
Imidacloprid (May not be used during flowering on	
crops pollinated by honeybees)	
Indoxacarb	
Spinosad	
Spirotetramat	
Thiamethoxam (May not be used during flowering	
on crops pollinated by honeybees)	
Approved Pesticides with Additional Application Re	strictions ²
Fumigants/Insecticides/Rodenticides for	Insecticides/Acaricides for Application of Ultra
Commodity Protection	Low Volume (ULV) Formulations
Aluminum phosphide	Deltamethrin (Only Non-RUP products)
Chlorpyriphos-ethyl	Dimethoate
Pirimiphos-methyl	Lambda cyhalothrin
Brodifacoum	Malathion
Permethrin	
Acaricides for Livestock	
Permethrin (Also permitted for use in warehouses)	

The following are additional AIs that do **not have registered products that are authorized for use in Niger** by the Sahelien Pesticide Committee (CSP). See Table B on next page. Upon approval of this PERSUAP by USAID and if products with these AIs become approved by the Government of Niger and the Sahel Insitute Pesticide Committee, they are permitted for procurement, use, and promtion by the Niger FFP programs. These pesticides are included within this PERSUAP becaue they are less toxic and more effective than many of the broadspectrum products currently approved for use in Niger.

¹ Application by GoN-trained and equipped phytosanitary brigade members only; promote farmer use of brigades, rather than self application. Also, neonicotinoid insecticides are approved only for application and use by phytosanitary brigade members and may not be during flowering on crops pollinated by bees. Only specific products with toxicity Class III or IV can be used on agricultural seeds and growing crops despite some active ingredients having products available with other toxicity classes.

² Fumigation and other warehouse commodity protection pesticides must be applied by approved and fully equipped Fumigation Service Provider. Acaricides for livestock must be applied by Ministry of Livestock and Animal Husbandry agents.

Table B: AIs without registered products by the CSP as of November 2014.

Approved Pesticides ³	
Insecticides/Acaricides	Fungicides/Bactericides
Horticultural oil	Bacillus subtilis
Methoxy-fenozide	Carboxin (Seed treatment only)
Nuclear polyhedrosis virus	Cyazofamid
Pymetrozine	Dicloran
Sulfur	Dimethomorph
Tebufenozide	Fluopicolide
	Fosetyl-aluminum
	Kresoxim-methyl
	Metalaxyl
	Pseudomonas fluorescens
	Sulfur
Approved Pesticides with Additional Ap	plication Restrictions ⁴
Acaricides for Livestock	Insecticides/Acaricides for Application of Ultra
	Low Volume (ULV) Formulations
Tetrachlorvinphos	Beta cypermethrin
Zeta cypermethrin	

4. Recommended Actions:

The following are the general compliance requirements for the programs. Each program is expected to comply separately with each element outlined within the PERSUAP. There are additional requirements related to pesticide use on crops and livestock, as well as for fumigation activities in the warehouse detailed in this PERSUAP's Environmental Mitigation and Management Plan, the Fumigation Safer Use Action Plan, and Fumigation Management Plan.

- Only pesticides approved by this PERSUAP may be supported with USAID funds in USAID/Niger FFP program activities. Among these pesticides, only products that are registered and approved for use in Niger by the Sahalian Pesticide Committee (CSP) of the CILSS, at the time of the intervention are permitted for program support by this PERSUAP. Pesticide "SUPPORT" means procurement, use, recommending for use, or otherwise facilitating the use of a pesticide.
- Pesticide support must be governed by locally adapted, crop- and pest-specific IPM plans and use restrictions for each of the four categories of pesticide use outlined in Section 3.1. Use restrictions dedicated to each use category are found in the factors of analysis (Section 3.3 a-1). The PERSUAP provides IPM plans in Annex 1 for further development and use by programs.
- The purchase of pesticides by any program-supported purpose must be from a GoN-certified pesticide supplier.
- Pesticide use supported by the program must ensure that applicators exercise care around sensitive non-target ecosystems (surface waters) and other areas (bee-keeping houses, etc.).
- For any pesticide use, the programs must ensure that pesticide wastes are disposed of following best disposal practices (see Section 6 on Safer Management of Pesticide Wastes).
- To the greatest degree practicable, programs must require use and maintenance of appropriate Personal Protective Equipment (PPE), as well as safe pesticide purchase, handling, storage, and disposal practices by all parties applying pesticides with funding from program activities.
- Programs must be systematic in their pesticide-related record-keeping and monitoring. The programs subject to this PERSUAP must provide an annual update on SUAP compliance.

⁴ See footnote 2 above.

³ See footnote 1 above.

USAID APPROVAL OF ENVIRONMENTAL ACTION RECOMMENDED:

CLEARANCE: Mission Director:	Susan Fine	Date:_	6/4/2015
CONCURRENCE: Bureau Environmental Officer: Approved:X Disapproved:	Erika J. Clesceri Erika Clesceri	Date:_	7/2/15
ADDITIONAL CLEARANCE: Activity Manager:	- cleared - Melissa Joy	Date:	5/21/2015
Food for Peace Acting Director:	- cleared by email - Susan Bradley	Date:	5/26/2015
Regional Food for Peace Officer:	H. Mariko (f. Robert Drapcho	Date:	6/01/2015
Regional Environmental Advisor:_	Kalim Hanna	Date:_	6/1/2015
Mission Environmental Officer:	Abdourahmane Ndiave	Date:_	6/1/2018

NIGER Agricultural Crop, Livestock, and Commodity Storage PERSUAP

(Revised March 30, 2015)

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Acronyms

Al Active Ingredient

AVRDC Asian Vegetable Research and Development Center

CEDEAO (fr.) Economic Community Organization for West African States (ECOWAS)

CFA (fr.) West African Franc

CILSS (fr.) Permanent Inter-state Committee for Drought Control in the Sahel

CG Care Group

CRS Catholic Relief Services
CSP Sahelien Pesticide Committee
DAP Diammonium phosphate fertilizer
DFAP Development Food Assistance Programs

EC Emulsifiable concentrate

EPA Environmental Protection Agency (US)
FAO Food and Agriculture Organization (UN)

FFP Food for Peace

EWS Early Warning System

FFS Farmers' Field Schools

GDP Gross domestic product

GEF UN Global Environmental Fund

GON Government of Niger
GUP General Use Product
HDI Human Development Index

Ha Hectare HH Household

ICRISAT International Center for Research in the Semi-arid Tropics

IITA International Institute for Tropical Agriculture

INRAN Institut National de la Recherche Agronomique du Niger

IPM Integrated pest management

IR Intermediate results

M Million

MCU Mother-Child Units

NGO Non governmental organization

PEA Programmatic Environmental Assessment

PERSUAP Pesticide Evaluation Report and Safer Use Action Plan

PIC Prior informed consent

PPE Personal protection equipment (clothing for using pesticides)

PVS Participatory Variety Selection

RECA Réseau National des Chambres d'Agriculture/Niger

RUP Restricted Use Pesticide (EPA)

SC Soluble concentrate
SG Soluble granules

SILC Savings and Internal Lending Communities

SO Strategic Objective (USAID)

ULV Ultra low volume

UNDP United Nations Development Program

USAID United States Agency for International Development

WASA West Africa Seed Alliance

WASH health, nutrition and water, sanitation and hygiene

WG Wettable granule

WHO World health organization

Acknowledgements

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Thanks are also due to the Chiefs of Party of Mercy Corps "Sawki" DFAP and Save the Children "LAHIA"
DFAP, and and respectively, for initiating the expansion of this report in
order to achieve a greater depth and breadth of analysis of pest management in each program.
Analyzing all of these food security fumigation and pesticide treatment issues would have been impossible without the direct support of the world-class experts and professionals in Niger and the three programs, which have helped guide data collection and interpretation.
and the Sun Mountain International team would also like to thank USAID Niger and the Sahel Regional staff, as well as USAID Africa Bureau and USAID Democracy, Conflict and Humanitarian Assistance Bureau Washington staff who will review this document.

SECTION 1: INTRODUCTION

1.1 PURPOSE AND SCOPE

In compliance with USAID's Pesticide Procedures (22 CFR 216.3(b)), this 2014 Niger Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP):

- Establishes the set of pesticides for which support is authorized for USAID/Niger Agriculture Sector activities.
- Establishes the requirements for support for these pesticides to assure that pesticide use/support (1) embodies the principles of safer pesticide use and, (2) per USAID policy, is fully within an Integrated Pest Management (IPM) framework.

These requirements come into effect upon approval of this PERSUAP.

The first sections of this analysis establishes the set of authorized pesticide active ingredients (Als) and requirements for safer use via the PESTICIDE EVALUATION REPORT (PER), which is an assessment of the 12 pesticide risk evaluation factors (a through I) required by 22 CFR 216.3(b).

The SAFER USE ACTION PLAN (SUAP) in Section 4 provides a succinct, definitive stand-alone statement of compliance requirements, synthesized from the 12-factor PER analysis. It also provides the required pest and pesticide management Environmental Mitigation and Monitoring Plan (EMMP), Fumigation Safer Use Action Plan, and Fumigation Management Plan (FMP) (Annex 2). The programs must monitor pest management, pesticide promotion, and fumigation activities as required by these plans and submit reporting data as part of the annual Environmental Status Reports (ESR).

This PERSUAP covers the following FFP Niger program activities that currently, or will in the future, involve promotion of improved pest management best practices involving pesticides for:

- Rain-fed, staple, and cash crop improved production;
- Vegetable and fodder production improvement, IPM and pesticide safer use training;
- Livestock health and sanitation; and
- Warehouse commodity protection.

If at any point throughout the implementation of the three programs, there are changes to the pesticide products or pesticide product uses that are to be promoted by the program, the individual program concerned will undertake an amendment to update this PERSUAP before promotion.

USAID/Niger Development Food Assistance Programs Pest Management Needs

In Niger, pests cause damage to stored warehouse commodities, livestock, and agricultural rain-fed, staple, and cash crops. For this reason, USAID/Niger Title II programs include a number of activities that require effective management of pests to achieve their objectives. Pests include arthropods and vertebrates, fungal and viral diseases, and nematodes. Typical pests, as related to the USAID Title II programs considered here, are extensively documented in Annex 1: Crop, Livestock, and Commodity IPM Plans. This annex makes clear that while non-chemical controls have a critical role to play, achieving USAID Title II program objectives is likely to require pesticide use and support. This need for effective pest management is not limited to the

period of performance of the programs, but is rather a continuing need for the long-term, sustainable improvements in agricultural productivity that USAID Title II programs seek to achieve.

1.2 DEVELOPMENT OF THIS PERSUAP

CRS initially contracted Sun Mountain International of Quito, Ecuador, to develop this "Stored Commodity, Livestock, and Agricultural Crop PERSUAP" for their "PASAM-TAI" project in Niger. James Litsinger was the Senior Consultant for developing the PERSUAP and was assisted by Sun Mountain International staff Mercy Nange and Tobias Carter in Niger and in office-based work and Luz Cervantes in office-based work.

While the CRS PERSUAP was under development, it was decided that the PERSUAP should also cover the two additional Title II Development Food Assitance Programs (DFAPs) in Niger, due to their shared requirement for a PERSUAP to cover Title II stored warehouse commodity fumigation and agricultural activities that support targeted pesticide uses. Thus, the "Sawki" program implemented by Mercy Corps Niger and the "LAHIA" program implemented by Save the Children International were included in this PERSUAP analysis to form an umbrella report for the three programs.

Mercy Corp's existing PERSUAP, "MC Niger Sawki Warehouse Pesticide Treatments & Fumigation," that has been approved by USAID was used as a reference during the fumigation-specific section of this PERSUAP. Furthermore, this report amends the requirements approved in that existing PERSUAP and serves as an expansion to the MC PERSUAP's coverage.

Methodology

The field work for the PERSUAP was conducted for the three programs throughout the first quarter of 2014 in order to explore pest management issues, document pesticide use, and identify and understand pesticide use regulatory frameworks and enforcement practices in the country. The assessment team met with key regulators of the agricultural inputs sector, public institutions involved in providing extension services to farmers, and private sector actors and non-governmental agencies in the pest management industry. Meetings were held with farmers and producer groups to gather information on their knowledge and practices in pest management and pesticide safety. Overall, practical pest management needs in the context of programs' interventions areas were gathered through soliciting input from key these stakeholders as outlined below.

Specifically, field work for CRS was conducted in Niger from January 20th - 30th, 2014. The assessment team collected information in Maradi and Matameye from January 20th - 25th and in Niamey from January 27th - 30th. Key informant interviews were conducted with representatives from the following institutions:

- CRS commodity, livestock, and agricultural crop management staff
- Ministry of Agriculture Department of Agricultural Extension and the Office of Plant Protection -Matameye departmental office
- Ministry of Environment and Agroforestry Matameye departmental office
- National Institute of Agricultural Research (INRAN)
 - Seed Production Department Maradi office
 - o Pesticide Registrar Niamey Office
- University of Abdou Moumoun Faculty of Agronomy in Niamey

- Agricultural input stores in program area
- Farmer cooperatives in Matameye part of program area
 - o Tounaride Cooperative (Tsaouni)
 - Tigaba Cooperative (Tassaou and Zongogassou)
- Reseau National des Chambres d'Agriculture du Niger (RECA)
- International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Sadoré Research Station

Field work for MC and SCI was conducted in Niger from March 26th - April 8th, 2014. The assessment team collected information in Niamey on March 26th and in Maradi, Aguie, and Zinder from March 27th - April 8th, 2014. Key informant interviews included representatives at the following institutions:

- MC and SCI commodity, livestock, and acticultural crop management staff
- National Institute of Agricultural Research (INRAN)
 - Researcher of pesticides under application for registration in CILSS Niamey office
 - Entomology Department Maradi office
- Director General for Plant Protection (DGPV)
 - Maradi regional office
 - o Department Deputy Director Guidan Roumji Department, Maradi
 - o Department representative Aguie Department, Maradi
 - Local DGPV agricultural extension agent Gangara, Aguie (Maradi)
 - Local Phytosanitary Brigade member Droum, Barriere (Zinder)
 - Two local Phytosanitary Brigade members Gangara, Aguie (Maradi)
- Ministry of Livestock and Animal Husbandry (DREL) Maradi
- Technisem, vegetable seed company Maradi
- Fumigation Service Providers
 - TaimaKon Manoma (Sawki) Maradi, Zinder
 - o Agrimex (LAHIA) Maradi
- Sawki Community Farmer Groups Maradi, Zinder
 - Men and womens' farmer groups Droum, Barriere (Zinder)
 - Men and Womens' farmer groups Guidan Sori, Guidan Roumji (Maradi)
- LAHIA Community Farmer Groups Maradi
 - o Farmer Field School (FFS) site and farmers Djallo, Guidan Roumji (Maradi)
 - Men, womens' farmer groups and FFS site Gangara, Aguie (Maradi)

In addition to the field work, the assessment team carried out a desk-review to determine toxicological profiles for each chemical provided in the PER 12-factor analysis, as well as non-chemical pest control measures that complement the recommended pesticide as part of an Integrated Pest Management framework.

SMTN staff reviewed the Sahliene Pesticide Comittees' and US Environmental Protection Agency's registration systems for pesticides, as well as compared findings in other PERSUAPs, such as the recently cleared PERSUAP "Covering CORAF/WECARD coordinated Feed the Future (FTF) Activities implemented by member National Agricultural Research Sysmtes (NARS) in West Africa".

It should also be explicitly noted that the products recommended and approved for promotion and use by this PERSUAP also have comparable products that are permitted for the same or similar uses in the United States.

SECTION 2: BACKGROUND

2.1 PROGRAMS COVERED BY THIS PERSUAP

This PERSUAP covers the following active Food for Peace Development Food Assistance Programs in Niger: CRS PASAM-TAI, MC Sawki, and SCI LAHIA. Each of the programs' scope of activities is described, briefly, below.

The Identified pest management needs for the three programs' Title II commodity protection, livestock, and agricultural crop interventions as well as the pest control measures analyzed and the attendant conditions for the use of pesticides are covered in Section 3.1: Pest Management Needs.

CRS "PASAM-TAI" Title II Development Food Assistance Program

The five year, \$40M (commodity and cash value) "PASAM-TAI" DFAP is implemented by CRS in close partnership with the Government of Niger (GoN). The overall goal of the program is reduce rural food insecurity and malnutrition in rural households in the Maradi and Zinder regions of Niger. The program seeks to address issues related to chronic food insecurity through the following Strategic Objectives and associated activities:

Strategic Objective 1 (SO1) is designed to improve health, hygiene and nutrition behaviors in households (HH) with pregnant and lactating women and children under 5, as well as to improve access to health, WASH and nutrition services. All Title II Commodity storage and protection activities fall under this SO1.

SO2 seeks to: increase and diversify vulnerable HH production of nutritious foods through activities such as training on homestead gardens and improved livestock management, activities that increase adoption of improved varieties of staple crops for consumption and income, training on Integrated Pest Management with demonstration plots, training on tree nursery management and tree planting, and and activities that improve post harvest storage and processing techniques, including cowpea seed storage. SO2 will reach 73,700 HH and enhance linkages between agriculture and nutrition, promote sustainability, and build resilience for the most vulnerable people. An additional 13,700 HH benefit from the learning opportunities, such as observing demonstration plots.

SO3 aims to improve integrated disaster risk management using community-based early warning system (EWS) to be integrated into the national EWS, as well as community managed disaster responses, while the Cross-cutting Objective of expanding gender roles is intended to enhance and sustain results.

CRS works closely with the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), and the federal agricultural research entity, the Institut National de la Recherche Agronomique du Niger (INRAN), for support in agriculture activities. The program engages GoN technical extension services in all sectors and community groups and leaders as the key program implementing partners. The program also will liaise with the West Africa Seed Alliance (WASA) for access to improved pest resistant crop varieties.

The Departments of Mayahi in Maradi, and Kantche in Zinder, were selected as the target intervention areas by CRS based on comparative need, return on investment, and accessibility relative to security risks. In addition, the Department of Kanche and part of the Department of Mayahi are located in areas favorable to drilling shallow wells and the DFAP will target areas characterized by a shallow water table (2-10 m). In areas where the water table is not deeper than 10 meters, treadle pumps will be promoted as a source for irrigation. There is high potential for irrigated land suitable for vegetable crops in these areas. CRS has selected 3 communes in Mayahi due to higher rates of rainfall that will improve the success rate for rain-fed crop activities. These communes are also contiguous to each other and have a higher population density than the more arid communes. The CRS program will target all 9 communes, however, in Kantche.

MC "Sawki" Title II Development Food Assistance Program

The "Sawki," program is designed to respond to the food security needs of more than 160,000 beneficiaries in two of the most food insecure regions of Niger: Maradi (3 communes) and Zinder (5 communes). Within these regions, the program will target 115 villages based on combined criteria of social vulnerability, economic opportunities and agro-pastoral linkages. Mercy Corps, Helen Keller International (HKI), and Africare have joined their expertise in Niger to deliver a comprehensive package of activities, supported through partnerships with the Government of Niger (GoN), local NGOs, INRAN, and the private sector. Sawki has the overall goal to "reduce food insecurity and malnutrition among vulnerable populations in Niger," with a special emphasis on empowering women and adolescent girls to achieve this goal. The program seeks to address issues related to chronic food insecurity through the following Strategic Objectives and associated activities:

SO1 aims to reduce chronic malnutrition among pregnant and lactating women and children under five. This will be achieved through improvement of nutrition practices during each beneficiary child's first 1,000 days, adoption of appropriate nutritition practices, and healthy timing of adolescent girls' first pregnancy, and counseling and appropriate care given by health centers and community actors. All Title II Commodity storage and protection activities fall under this SO1.

SO2 seeks to improve and diversify household nutrition, income, and resilience to shocks through activities diversifying agricultural productivity. This will be achieved through activites, such as training on micronutrient-rich products production, preparation, processing, and conservation, providing vouchers for inputs or services to women's garden participants, and performing activities that increase land and livestock productivity at household and community levels.

SCI "LAHIA" Title II Development Food Assistance Program

Save the Children International (SCI), in partnership with World Vision International (WVI), co-implement the Livelihoods, Agriculture and Health Interventions in Action (*LAHIA*) project to address Niger's food insecurity and vulnerability in the Maradi region of Niger. The overall goal of the project is to reduce food insecurity and malnutrition among 17,972 poor rural households in three communes of the Aguié District (Aguié, Tchadoua, and Gangara) and two communes of the Guidan Roumdji District (Guidan Sori and Sae Saboua). In adherence to USAID/Niger and FFP programming priorities, the program conducts a package of activities designed to address the sources of malnutrition among pregnant and lactating women and children under 5 and increase household food production and income. *LAHIA* plans to achieve this goal by improving nutritional status of

children under 5 years of age and pregnant and lactating women, increasing access to food by vulnerable households, reducing vulnerability to food security shocks, and improving the status of women within target households and communities. The SCI program has the following Strategic Objectives and associated activities:

SO 1 will focus on increasing key maternal child health and nutrition practices (MCHN), increasing use of MCHN services and increasing access to potable water and sanitation facilities. All Title II Commodity storage and protection activities fall under this SO1.

SO2 aims to Increase access to food by vulnerable households. The agricultural interventions under SO2 to increase access to food to vulnerable HHs will be achieved through three main activity types. With respect to livestock, the traditional "kiyo" system to lend female goats on a revolving basis to women will be built on. For each of the original 970 program-sourced goats, the cascading affect of kiyo will reach at least 7,500 very poor HH. Community Animal Health Workers (CAHWs) will be instructed on the good animal health and management practices and pass this instruction on to beneficiaries. A "modified" Farmer Field School (FFS) approach to increase farmers' (men and women) use of improved agricultural and natural resource management practices will be employed. Knowledge will be transferred through demonstration plots, community radio and drama presentations, peer visits, and bi-annual farmer days. Input packs will be provided to trainers and consist of improved seeds, tools, and fertilizer that FFS members will use in their first year of participation in the FFS. LAHIA has also identified cowpea through a value-chain analysis as an optimal crop for direct support and promotion as a cash-crop.

Reduction of vulnerability to food security shocks under SO3 will be achieved though improvement of communities and communes capacity to respond to, monitor, and mitigate shocks. Improvement of status of women within target households and communities under the Cross-cutting Objective will entail improving staff and community capacity to address gender equity and strengthening gender capacity across sectors.

2.2 COUNTRY AND PROGRAM AREAS BACKGROUND INFORMATION

The Development Food Assistance Programs' technical interventions in agriculture present an integrated approach to reducing chronic and acute food insecurity and malnutrition, improving livelihoods, and protecting against shocks in two regions of Niger: 1) Maradi and 2) Zinder. FFP identified Maradi and Zinder as priority geographic regions based on data for stunting, wasting, historical food crises, and poverty.

Geography & climate

Niger is a large landlocked country of 16 million people within the Sahel region. The Sahel is the transition zone between the Sahara desert to the north and the Sudanian Savanna to the south. Niger is the fifth largest country in Africa by area and about 88% is covered by the Sahara desert. In the extreme south, on the edges of the Niger River basin, there is a tropical climate. The terrain is predominantly desert plains and sand dunes, with flat to rolling savanna in the south and hills in the north. The encroaching desert threatens agriculture in the savanna. Niger is prone to natural crises - notably droughts, floods, and locust infestation - all contributing to chronic food insecurity.

The Maradi region holds 20% of the population, living on 3.3 percent of the country's land. The Zinder region borders the Maradi region to the east. These regions, for the most part, are part of the Sahel ecological zone, which is estimated to have an annual rainfall of 350-600 mm. In general, the Sahel ecological zone covers is suitable for agriculture and has a highly-concentrated human population.

Water resources

Niger has approximately 2.5 billion cubic metres of underground renewable water; however, only 20 percent is currently exploited (IRIN 2006). In addition Niger also has the Niger River, the Komadougou River, and Lake Chad. 90 percent of Niger's surface water, though, originates outside of the country according to the International Water Association (2013).

Rainfall in the region has decreased by as much as 50 percent in the past three decades and desertification has compounded the problem. Access to water has been an ongoing struggle for many. Because of this, some believe conflict could become an issue especially since Niger shares water resources, such as Lake Chad and the Niger River, with several other countries.

Socio-economic context

Niger is one of the world's poorest countries. 56% of the population lives in poverty, and with the per capita income at US\$360 per year, it lies near the bottom of the United Nations Development Program (UNDP) Human Development Index (167th out of 169 countries in the 2010 HDI). Despite having some of the world's largest uranium deposits, for most of the population the economy is centered on subsistence crops and livestock.

Chronic and acute food insecurity

Chronic and acute food insecurity and malnutrition continue to impact the livelihoods of the most vulnerable Nigeriens. Roughly four in five Nigeriens are fed by subsistence farming in a region experiencing great challenges to subsistence farming. Widespread millet-crop failures in 2011 and the compounding effects of previous droughts, locust attacks, or weevil infestations in stored food have led to a dangerous reduction in food for between 25-50% of Niger's agro-pastoralists. Furthermore, chronic food insecurity is exacerbated by vulnerability due to socio-economic conditions, gender inequalities, recurring shocks, poor governance and low literacy.

The comparative need of the selected program areas, as described above, was defined in terms of chronic malnutrition and food insecurity, with weight given to higher chronic malnutrition. Maradi and Zinder account for 40% of national cereal production; however, the regions do not meet their HH food needs. Even in high production years, the most vulnerable HH only meet cereal needs for six months per year and spend about 71% of their income on food.

Using the CRS program areas as an example, agriculture is the primary source of revenue for over 84% of respondents, followed by small ruminants at 44%. Cultivated land has increased, yet cereal yields are stagnant due to poor soil fertility, production, handling and storage, and environmental management practices. In the region the rate of chronic malnutrition in Mayahi is 69% and food insecurity is nearly 50%. Chronic malnutrition in Kantche is 76% and is the highest in Zinder despite having a low rate of food insecurity at 34%.

Education

In 2005, the literacy rate of adults in Niger was of 28.7% with a considerable difference between men (42.9% literacy rate) and women (15.1%). In 2012, primary school completion rate was 43.1 for females and 55.3 for males. However, secondary education completion rates are significantly lower with an enrollment rate in secondary programs of 9.7% for females and 14.7% for males, according to 2011 World Bank data.

Gender

Gender inequality is Niger is widespread and varies in severity between ethnic groups. Within the household setting women are generally discriminated against and tasked with the majority of household chores in addition to child rearing.

Women do not have the same legal status as men in the traditional and customary courts. For example, women have limited rights to ownership or possession of land. Accounts show that women in the Zinder region in Niger cannot inherit land because of the way the Quran is interpreted by local religious authorities (SNV Practive Brief, Issue 4). Women can borrow or lease land to grow crops, but in many situations this has led to losses because they were obliged to make payments with part of their harvest. In addition, their access rights can be revoked at will by land owners.

Agriculture

Agriculture contributes about 40% to NigersGross Domestic Product (GDP) and provides the source of livelihood for about 90% of the population. Most of the Nigerien population is rural and relies on rainfed subsistence farming. Currently, only 0.5% of cropland is irrigated, significantly limiting productivity. The agricultural economy is based largely upon internal markets, subsistence agriculture, and the export of cowpeas, onions, and cattle to neighboring countries.

Livestock production

Livestock production (camels, goats, sheep and cattle) supports 29% of the population. More than one million people are working full-time in livestock production, and more practice an agro-pastoral mix of farming and livestock rearing activities throughout the year, principally in northern Niger.

After uranium, livestock is the second largest export product of Niger. Nigerien livestock production is based on extensive grazing, but climatic changes, the extent and quality of pastures, sanitary and economic constraints set limits to its performance. The precarious economic and production situations along with the climate, favors camels and small ruminants (goats and sheep). Small ruminant production has doubled since the 1960s, with sheep having increased more than 70 percent in the last twenty years, although the number of goats is currently still greater. Due to their high rates of breeding and proliferation, small ruminants are favored since a drop in number after a drought can quickly be rebuilt.

Characteristics of agricultural systems

Traditional West African agriculture is characterized by small farms, mixed crops, and heterogeneous crop germplasm (Youm et al. 1990), including Niger. Efforts to increase food production in Africa previously emphasized developing technology for large-scale farming, and it omitted socioeconomic systems in rural communities. Traditional, multiple cropping systems were thought to be less productive than large-scale

monoculture. However, multiple cropping is a vital factor in the food supply in Niger and contributes to increased agricultural production. Crop production in traditional farming systems are faced with constraints, such as availability of water and soil fertility. Furthermore, poor and nonproductive soils and the high cost of pesticides in developing countries often make pesticide purchase and use of marginal economic benefit.

Insect-susceptible grain legumes, such as cowpeas, are often mixed with cereals to reduce pest damage to rosette virus of cowpea. The presence of tall cereal crops, interspersed with low-lying legumes, such as cowpea and groundnuts, restricts insect pest movement (Litsinger and Moody 1975). Mixed cropping has been ranked as one of the most widespread cropping approaches, and it gives the farmer higher overall yield and greater returns than pure culture cropping, where poor fertility of sandy soils is a major constraint.

Despite the popularity of intercropping systems, crop losses remain high partly because the natural resource base is highly degraded. National statistics show that crop yields per hectare have consistently decreased over the last two decades due to soil degradation, population growth, and unsustainable farming practices. Land pressure also pushes farmers onto marginal lands, contributing to desertification. Fertility and water holding capacities of the soil need to be improved, as well as crop varieties. Nigerien farmers need to produce compost to increase the organic matter content of soil and to establish windbreaks of trees to stop wind erosion. More research support is needed to develop improved varieties with broader pest resistance, as well as to identify biologically based pest control measures.

Government interventions

The government's key agricultural programs seek to: 1) Diversify agricultural production to increase cereal yields; 2) Use improved seed varieties that mature early and are better able to withstand erratic weather; 3) Irrigate more land; and 4) Collect, store and transfer milk from the north, which often has a surplus, to the south, which relies heavily on powdered or imported milk.

Soils

In the extremely dry areas in the north and northeast of Niger, scarcity of water and vegetation inhibits soil formation. Further to the south, a large strip of sandy soils crosses Niger from Mali to Chad. The slightly weathered soils show thin layers of clay accumulation in the central and western part of the country (Arenosols). As rainfall and weathering continues overtime, these soils start to show a light colored upper horizon with little organic matter, and a reddish lower horizon due to a higher iron-concentration. Arenosols have low water retention but are permeable and easy to work. They have a low natural fertility, a low cation-exchange capacity and deficiencies of minor elements are common. These soils may erode easily by wind and water as soon as vegetation is gone. These arenosols are the main soil types in the project areas and are suitable for agricultural crops, such as millet or groundnut, that demand limited nutrient and water inputs.

Sahelian farmers are among the poorest population on earth largely because more than 50% of the Sudano-Sahelian land is degraded and not suitable for cultivation. In most cases the degraded land is composed of crusted lateritic soils impermeable to water. This scarcity of cultivable land means food insecurity and poor nutrition, a matter made worse by the rapidly growing population in this region. Shortage of good farmland has led to a number of innovations to farm marginal, often laterite soils and soil degraded by overfarming, wind, desertification, and drought. Women in particular are often given poor plots of land (in inherited sections known as Gamana) to garden, and have developed specific crops for poor soil and water conditions.

External organizations have tried introducing alternative crops, such as the fruit of the *Ziziphus mauritania* tree ("Indian Jujube", marketed by ICRISAT under the name of "Pomme du Sahel" or Sahel Apple) and Moringa oleifera. Farmers use specialty water conservation techniques, water micro-catchments, or planting pits known as zai holes, planting of crops among certain trees, planting in raised beds, drip irritation, and usage of water collected in the natural stone bottomed water-catchment areas common in the south east of the nation.

2.3 NATIONAL REGULATION AND MANAGEMENT OF PESTICIDES

Regulatory Framework

The Permanent Interstate Committee for Drought Control in the Sahel (French acronym CILSS) is an international organization consisting of nine countries in the Sahel including Niger. CILSS established a Common Regulation for Pesticide Registration that combines the national expertise and capacity for pesticide evaluation, registration, and management of all CILSS Member States. The Sahelian Pesticide Committee (CSP) became operational in 1994. It assesses registration dossiers submitted by agrochemical companies and grants sales permits valid for use in all its Member States. Harmonized tests and field trials have been established, and regional laboratories for conducting pesticide analysis are in operation.

The CSP registration system operates with one full-time technical staff and has funding from national governments for each country's Committee members. The CSP consists of experts from all member countries that meet twice a year to evaluate submissions for the registration of pesticides. The Permanent Secretariat is based at the Institut du Sahel in Bamako.

The legal backing for pesticide regulations are formed by the Pesticide Act and Pesticide Regulations for Niger that was developed through the CSP and is standardized for each member country. Companies that want to register a pesticide need to apply for registration in at least two Sahelian countries.

The system of pesticide registration became more complicated in 2008 when the Economic Community of Western African States (CEDEAO in French) was formed. The new arrangement includes new countries, such as Nigeria and Ghana, into the regional organization. CEDEAO is divided into two sub-organizations, a northern Sahel grouping that includes Niger and a southern Humid Zone grouping including Nigeria and Ghana. The Sahelien countries have agreed to phase out and replace CSP with CEDEAO. There is a transition phase ongoing now to achieve this end.

Pesticide Registration

Pesticides can only be registered by the CSP if they have been previously approved by countries within the European Union (EU) or North America. A provisional permission for sale over a period of three years has been granted by the CILSS authorities in some instances for chemicals not approved in the EU or North America.

A division of tasks has been agreed upon between regional and national levels that fall under preregistration, registration, and post-registration phases. Pre-registration are mainly limited to a requirement for pesticide efficacy trials. These are carried out by national agricultural research institutes and funded by the agrochemical industry. CILSS has harmonized the experimental requirements for these efficacy trials and full exchange between member countries of the results. The test protocols have been brought in line with European Union standards, and the registration system now follows principles of pesticide safety outlined in international conventions such as the WHO/FAO International Code of Conduct on the Distribution and Use of Pesticides, the Rotterdam Convention on the Prior Informed Consent (PIC), and the Stockholm Convention, which bans Persistent Organic Pollutants (POPs).

The CSP has now registered and approved several hundred pesticides and the list is ongoing as re-registration is required every five years for every pesticide brand. One recent review categorized the registered pesticides in terms of pesticide hazard, with 5% in the highest toxicity level I, 49% in II, 39% III, and 7% in IV.

Regulating Pesticides

Within Niger, it is the Ministry of Agriculture's DGPV (Director General for Plant Protection or Direction Generale sur la Protection des Vegetaux) that regulates the pesticides approved by the CSP. The DGPV also sends out field agents to ensure that the products sold by certified agro-dealers solely include products that have been approved, and agro-dealers run the risk of having the non-registered products confiscated in the case these local agents discover otherwise. Unfortunately, unregistered agro-input dealers are common in Niger, and the cheaper prices of their unauthorized Nigerian products attract farmers.

Challenges with Pesticide Management

The main bottleneck in pesticide management in the Sahel is control and enforcement of measures laid out in legislation. Effective control is almost completely lacking and the main problem seems to be a lack of trained staff and funding. Due to the lack of comprehensive import and use statistics, it is not possible to estimate the magnitude of pesticide use that occurs in Niger. Funding mechanisms, such as pesticide import levies, are not being used to fund the solutions to these problems. Another constraint is a lack of laboratory facilities for pesticide residue analysis and formulation quality control.

Many problems with proper product labeling exist. Labels should be in French, but many are in English or other languages. Some were found to lack the name of the manufacturer or distributor on the label. According to a pesticide evaluation study carried out by RECA from January-March 2013 entitled "Insecticides/acaricides disponibles pour la protection des cultures: Premier inventaire", many of the products inventoried have English labels or mention pests that are not specific to Niger. Of the 106 products that were inventoried, 71 of them had labels that showed the country of fabrication (55% of the products were made in China) and 78 of them had distribution centers in Africa (53% in Nigeria, 24% in Ghana, and 7% in Niger). The study also uncovered several cases of mislabeled, adulterated, fake or imitation products, such as the example of a fake product called Labda Super 2.5 EC which had the same package as the very popular pesticide Lambda Super 2.5 EC. There were also cases of products with highly toxic active ingredients, such as endosulfan, that have been banned by Niger, or unknown active ingredients such as bisultap, which is of Chinese origin. The majority of the products found by the study were authorized for use in Nigeria and Ghana, but only 6 of the 106 products had been registered for use in Niger by the CSP (i.e. 95% of inventoried products were not registered for use in Niger).

The Ministry of Agriculture Plant Protection Service has inspectors that are charged to visit agro-input dealers to ensure that all products are registered, but this has proven overall inefficient. Most pesticides are bought in Nigeria and transported to Niger by farmers or local dealers without passing customs. Verifying registration of products is very difficult due to the number of traders.

Many illegal, fake, and non-registered brands of pesticides enter Niger from neighboring countries or are produced within Niger, according to stakeholder reports. A recent study by the extension services found that from a total of 149 pesticide brands available in the market, only 13% were registered in Niger. Of the others, 40% were from Nigeria, 35 % from China, 13% from Ghana, 8% from India, and 4% from other countries.

Trans-border movement of pesticides both in import and transport of expired product containers are other issues. Pesticide import transactions do not go through the customs service and can be imported without a permit, as is required in some countries. The government has no records of these transactions and cannot produce data on pesticide importation and consumption. Legally-speaking, obsolete pesticides are supposed to be returned to the company that registered the product. The Ministry of Agriculture, however, now has 40 tons of obsolete pesticides that require transportation by truck to Senegal for incineration.

SECTION 3: PESTICIDE EVALUATION REPORT (PER) 3.1 PEST MANAGEMENT NEEDS

This section provides key information that serves as critical input to the 12-factor analysis undertaken in Section 3.3: PER, 12-Factor Analysis. This current section, however, includes the list of target crops considered in this PERSUAP, their pest management needs, and findings from the field for each class as described below.

Four Classes of Use

According to the activities of each program, the necessary or potential support of chemical pesticides can be categorized into four different use classes, based on the target types of crops and products in relation to the proposed users. The four use classes include all pesticide promotion and use activities that may arise during implementation of the three programs. Specific use conditions are also included for each of the four use categories. The conditions for each category of pesticide promotion or use apply to all programs that intend to implement interventions that fall within one of the four use categories. The pesticide use classes are:

- Rain-fed, staple, and cash crop improved production;
- Vegetable and fodder production improvement, IPM and pesticide safer use training;
- Livestock health and sanitation; and
- Warehouse commodity protection.

The pest management needs that are part of these different use classes are summarized below and documented in detail in **Annex 1**: Crop, Livestock, Commodity IPM Plans.

Rain-fed, Staple, and Cash Crop Improved Production

Central to each food security program's objectives is the improved diversification and productivity of rain-fed crops. These crops are traditionally the backbone of nutritution and income in the program areas. While pest management needs vary significantly among rain-fed crops supported by the programs, pesticides have been proposed as an important safeguard in addition to the suite of non-chemical control methods being promoted to protect these valuable crops (see Section 3.3). Cowpea, for instance, has been identified as a crop that is particularly well suited for promotion as a cash crop. It is, however, more vulnerable than others

to numerous rainy season pests. Thus, program activities will include the promotion of specific pesticides as part of activities that effectively help farmers improve their crops and their knowledge and application of safer pesticide use practices.

In the context of direct support to improve rain—fed, staple, and cash crop production, the programs should support pesticide use on an as-needed basis only, and should not support farmer self-applicatation of pesticides. The programs will not supply farmers with pesticides, or application and safety equipment. They will instead utilize the existing GoN agricultural extension system for providing regulated pest management services, namely, use of the GoN-trained and epuipped phytosanitary brigade members.

Support of these brigades needs to be coupled with efforts to improve the brigades' capacity for pest identification, monitoring, and the use of economic thresholds in determining pest management needs for farmers.

Currently, the programs do not have the internal capacity or budget plans for self-application, which is in part the reason only spray brigades will be strictly utilized and promoted in this PERSUAP. Furthermore, it should be noted that in all the villages with Farmer Field School (FFS) demonstration plots, there is a brigadier present. The programs feel it is imperative to reinforce the role of the GoN-trained and epuipped phytosanitary brigade members as the go-to applicators for program-supported pesticide use in all settings. This strategy aligns with all the programs' needs and objectives for long-term sustainability, as well.

Rain-fed, staple and cash crops

- Cowpea (and other beans)
- Millet
- Sorghum
- Groundnut
- Maize

Pests and Pesticides

Pesticides permitted for management of specific pests of the above-listed crops are detailed in the 12-factor analysis (Section 3.3). Use of these pesticides is only permitted for the crop/pest specified in Annex 1, and with the specific application conditions stated in the SUAP (Section 4).

Findings from field work

A majority of farmers involved in the cultivation of rain-fed crops, such as millet and sorghum, cannot afford pesticides, and depend on the local brigade to spray their crops in case of pest infestation. The brigades, subsidized by the Government of Niger and supervised by the local office of the DGPV, are provided with pesticide use training, adequate Personal Protective Equipment (PPE) and pesticides by the DGPV (mainly acetamiprid, deltamethrin, dimethoate, and lambda-cyhalothrin). The GoN-trained and epuipped phytosanitary brigade members mix the products at their office/pesticide store and select the product based upon the pests to be targetted before heading out to the farm site. GoN-trained and epuipped phytosanitary brigade members are paid a commission for their services, ranging from 1000 FCFA for four hours of work in the morning to 500 FCFA for two hours in the afternoon.

Unfortunately, not many farmers can afford to call on the brigades, and so an estimated 90% of farmers do not apply pesticides during infestations, and rely on traditional methods of pest control, such as manually catching and burning pests, or they buy cheaper, unregulated products from independent vendors and apply pesticides themselves without proper equipment and poor practicies. For this reason, it may be necessary for the programs to work with departmental and local DGPV offices to create a system for improving the accessibility of regulated pesticides to farmers. One such system, proposed numerous times during field visits when in discussion with program and DGPV staff, is for the programs to purchase and supply pesticides to the DGPV office so that farmers could contract spraying services at a subsidized price. The particular advantage for the program would be the replacement of the use of broad-spectrum, high toxicity products, (currently preffered by farmers because of their immediate, visible affect) for the safer, more targetted products approved and recommended in this PERSUAP.

Overall, the brigade pesticide application program provides farmers with a means to combat pest infestations in a relatively controlled and safe manner. However, such application in a farmer's field without any basis, such as economic thresholds or sampling, is likely to create problems, such as disruption of the environment or pest/natural enemy unbalance. Such practices also convince the farmer that "chemical control is the only effective way in dealing with their pest problems" (Youm et al. 1990).

Despite lack of capacity in pest monitoring, programs are committed to promoting use of brigades, instead of farmers attempting self-application of pesticides. Pesticides procured and promoted by the programs should only be accessed by farmers through the DGPV and handled at all stages by extension services and GoN-trained and epuipped phytosanitary brigade members. Additionally, the programs should stress that farmers should not obtain pesticides from unofficial sources, as well. Unofficial pesticides may be tampered with in a number of ways and may pose additional risk to anyone handling them, even with otherwise proper PPE. They may be especially harmful to crops and ecosystems because their toxicities and concentrations may be adulterated.

It should be noted that according to the Maradi regional office of the DGPV, high quality products may be legally purchased in Nigeria or from Nigerian distributors, as long as the formulation of the product is equivalent to a product that is registered in Niger. Determining high quality is somewhat subjective, and the DGPV has classified different levels of quality of Nigerian products based on the distributor's reputation, the product packaging and whether they follow Nigerien regulations about the information contained on the label. The DGPV or the Nigerian Ministry of Agriculture must be consulted if the programs were to choose to explore buying Nigerian products.

Migratory pests and government ULV control

The Plant Protection Department (DGPV) conducts large campaigns against migratory pests, such as locusts, army worms, and quelea birds. Locust infestations are generally not severe in any of the three programs' intervention areas, but are worse in regions further to the north. Locusts attack millet and sorghum but will eat anything green. In 2013 there was a budget to aerially treat 300,000 hectare (ha) from locusts; of that, 250,000 ha of cereals were to be protected in the rainy season and 50,000 ha of vegetables (cabbage, potato, maize, sweet pepper, onion, cucurbits, and tomato) were to be treated during the dry season. There are four aircrafts for such operations, outfitted with ULV sprayers. Smaller infestations are taken care of by local Brigades using handheld ULV sprayers or outfitted truck units. Spraying by truck requires 0.5-1 liter

insecticide/ha, while spraying by air requires 0.5 insecticide/ha, and spraying by brigade requires 2.5 insecticide/ha.

GoN-trained and epuipped phytosanitary brigade members are fully equipped with proper PPE. People are advised by the local brigade to leave the area during the spray event at least 3-4 days before the spraying occurs. This gives villagers enough time to evacuate if their living areas are too close to the subject agricultural feeds. However, villagers who do not heed the warning to vacate the area may be put at risk from migratory pest control activities, as this aerial application is particularly harmful to human health and ecological systems.

While government large-scale pest control campaigns are outside of the jurisdiction of this PERSUAP, the programs should advocate for smaller scale, incongruous ultra low volume (ULV) pesticide spraying throughout the program areas, by contracting government spraying using handheld ULV applicators only.

Vegetable and Fodder Production Improvement, IPM, and Pesticide Safer Use Training

As part of the programs' efforts to diversify agricultural production, especially small-scale, irrigated vegetable crops grown in the dry season for marketing and home consumption, pest management trainings are to be carried out by each program. As many beneficiary farmers have never grown the crops being promoted before, or have not attempted to grow them in the dry season, their knowledge of the pests that affect them and the control measures available to them are extremely limited. The programs have acknowledged the tendancy among farmers to expect pesticides to be the best solution to pest problems. For this reason, knowledge of appropriate pesticides, their risks and their safe use is an important component of IPM training and there is an identified need to sensitize farmers to these aspects of pesticide use as part of an IPM program.

This PERSUAP approves many active ingredients that are targeted to very specific pest problems of certain crops. These products are approved so that the programs can educate farmers (and potentially GoN-trained and epuipped phytosanitary brigade members involved in said trainings) to the uses of pesticides in an IPM program and include them in field exercises that demonstrate proper use, including demonstration of proper handling, mixing proper dosage, application, correct equipment use and maintenance, and disposal. Direct-support of pesticides for staple crops is permitted only if application is conducted by GoN-trained and equipped phytosanitary brigades as described above.

As required in SUAP, Section 4, safer pesticide use training, and as part of an IPM training, programs must inform farmers of the mechanics and the rationale of utilizing this GoN service. Programs are required to only use the phytosanitary brigade for any pesticide application that is part of any of the three Title II programs' crop production or fodder production activities.

Dry-season vegetable crops in addition to fodder (and cotton)

- Okra,
- Tomato,
- Egglplant,
- Irish Potato,

- Sweet Potato,
- Onion and Garlic,
- Cabbage,
- Lettuce,
- Cucurbits (squash, watermelon, pumpkin),
- Carrot.
- Sesame,
- Moringa,
- Apple of the Sahel,
- Hibiscus.

Pests and Pesticides

Pesticides permitted for management of pests of these crops (and fodder and cotton) are detailed in the 12-factor analysis (Section 3.3). Use of these pesticides is only permitted for the crop/pest specified in Annex 1, and with the specific application conditions stated in the SUAP (Section 4).

Findings of field work

Farmers already involved in the market gardening of vegetable crops, such as tomatoes, onions and lettuce, often depend on pesticides to produce pest-free produce that fetch better prices on the markets. Many either travel to the nearest vendor in Nigeria, such as in Cano, Nigeria (located about 30 minutes away from Matameye), or buy pesticides from travelling vendors who come north from Nigeria to meet the demand (typically in the rainy season). This remains a strong disincentive against buying local authorized products from legitimate stores, where prices are higher. Some 86% of them get their knowledge of the use of pesticides through these Nigerian agro-dealers and other farmers, rather than government extension agents.

Most farmers apply pesticides to their crops without specialized equipment (using a bucket and twig) or without any PPE as they do not perceive pesticides as a health hazard (in spite of reports of skin rashes, bouts of sneezing, dizziness, and the death of a pesticide applicator after spraying too much with no PPE whatsoever and reports of children who died after drinking water from empty pesticide containers), and failing to respect the re-entry interval (REI) recommendations after spraying.

Mitigating farmer risk by promoting and eliminating barriers to using PPE should be a central concern moving forward with all agricultural input related implementation. As mentioned above in the discussion of staple crops, the barrier to safer application should be addressed through efforts to increase the accessibility of the existing GoN extension brigade's spraying services and increasing farmer's access to products approved by the GoN.

Other observed issues are the use of seed treatment as dust formulations, as farmers heaped pink dyed powders with their bare hand on cabbage heads, a practice which results in application rates 2-3 times higher than recommended, leading to health risks for humans and poor control for cabbage pests. Some farmers of rain-fed crops that were interviewed claimed to follow REI recommendations given by the Brigade (varying from one day or until after the next rains) before resuming hand weeding. Other farmers involved in market gardening also said that they could re-enter the field immediately after spraying.

Generally farmers place too great an emphasis on using pesticides. A basic lack of pest management knowledge among farmers contributes to overreliance on pesticides. Most farmers lack the skills of recognition and monitoring of the most of the common pests on the crops they grow, which is critical information in pest control decision-making. While pesticides were clearly heavily favored, some farmers are already using homemade or simple ways of controlling pests, such as the use of neem, garlic, soap, kerosene, and chili extracts, thanks in large part to the efforts of the programs' trainings.

IPM is seen throughout the Sahel as a way to reduce the reliance on pesticides, to increase revenues for farmers, and develop more sustainable agricultural production systems. There have been a number of regional IPM initiatives that have trained a large number of researchers, technicians, and extension staff in IPM techniques and approaches. The participatory FFS model has been established by the FAO in Maradi in recent years. From 2009 to 2011 15 new technologies were tested for the development of cowpea production in six villages in southern Niger training 107 farmers, half of whom were women. The addition of animal manure or mineral fertilizers led to a yield increase of 5% to 317%. Botanical insecticides, such as neem seed extracts, and pepper have been shown quite effective against important field pests of cowpea. It was identified that a combination of 5 to 6 technologies can increase the yield of cowpea from 9% to 171%. (Baoua et al. 2012). This effort while laudible is insignificant given the large number of farmers that need to be trained.

Continuing to promote a more integrated approach to pest control will not only provide a more sustainable means of pest control, but also prevent the development of pest resistance to certain pesticides. Farmers are generally unaware of the problems that accrue from a continued dependence on pesticides. Fortunately, the problems inherent in a pesticide dependence treadmill have not yet played out in farmers' vegetable production to the same extent as they have already in cotton. Pest of cotton crops in Niger already have developed of pesticide resistance and secondary pest outbreaks are problematic.

Livestock Health and Sanitation

A key component of the three programs is promotion and improvement of livestock management. Maintaining healthy livestock and preventing spreadable diseases or pest outbreaks is essential to the success and sustainable benefits of the livestock promotion activities. Each program will be advancing interventions to improve community capacity for sustaining healthy herds of animals. Training and equipping of Community Animal Health Workers (CAHWs) will have the benefit of spreading knowledge of best practices to prevent pest problems in the field and to provide communities with the means to address problems that arise before they lead to problems that require pesticide treatments. "Paravet" activities by the program will include the distribution of the same animal health kits, but these health kits will include no pesticides.

According to program livestock experts the local adaptation of the animal varieties being promoted by the programs, as well as the specific climatic conditions in Niger, mean that there is minimal threat of pest outbreaks among livestock, especially if best livestock hygiene and management practices are followed. It was also determined, however, that the need for pesticides could arise and the risk would be greatest when

animals are in their greatest densities, such as during times of animal breeding and during distribution of animals to beneificaries.

If a need for pesticide use arises to prevent or control a livestock pest outbreak, *trained and certificied pesticide agents of the Ministry of Livestock and Animal Husbandry will be the only permitted users of specific products approved by this PERSUAP for use on animals*. At no time will the programs build the capcity of the beneficiary farmers on the use of pesticide treatments on livestock given the weak capacity of beneficiary farmers to follow safe pesticide application and use procedures.

List of livestock targeted

- Large ruminants (cattle, cows),
- Small ruminants (goats, sheep),
- Poultry (chicken, guinea fowl).

Main economically impactful pests of livestock

Acarian species, such as ticks or louse.

Pesticides

Pesticides permitted for use against pests of livestock are detailed in the 12-factor analysis (Section 3.3). Use of these pesticides is only permitted for the crop/pest specified therein, and with the specific application conditions stated in the SUAP (Section 4).

Findings from field work

During an interview with the Department of Livestock and Animal Husbandry of Matameye, it was mentioned that certain highly toxic products were still being recommended for use by the veterinary services of the Department. For instance, lindane, a highly toxic pesticide and known carcinogen, is recommended for use as a dust for poultry, sheep, and goats in spite of the fact that it can penetrate the skin of animals and remain in the meat consumed by people. Lindane is rejected for use by this PERSUAP. Futhermore, programs should raise awareness among beneficiaries, as well as their partner government ministries, against the use of lindane, due to its possible effects on human health.

Also, systemic avermectins (ivermectin), which is a very effective acaricide is recommended by the Livestock Department to combat ectoparasites. This product if used both internally and externally too much can result in a high risk for acaricide resistance, with the result that neither internal parasites nor ectoparasites will be controlled. This PERSUAP will only be recommending formulations no greater than 1.9%.

Commodity Warehouse Protection

A key component of the three programs' SO1 is the storing of commodities in warehouses for distribution to beneficiaries. *Only approved fumigation service providers (FSP) are permitted by this PERSUAP to engage in fumigating of warehouses*, and these FSP must adhere to the requirements outlined in the PERSUAP.

Products being stored

CSB (Corn Soya Blend) Plus,

- Vegetable oil (4 liter tins),
- Soy-fortified bulgur wheat (SFBW),
- Lentils,
- Yellow split peas,
- Grains (wheat, rice).

Pests of stored commodities

The primary invertebrate insect pests of stored products (listed just above) are:

- Bean weevils Acanthoscelides obtectus and Callosobruchus maculatus,
- Khapra beetle Trogoderma granaria,
- Lesser Grain Borer, Rhyzopertha dominica,
- Flat Grain Beetle, Cryptolestes species,
- Merchant and saw-tooth grain beetles *Oryzaephilus* species.

The primary invertebrate insect pests of **stored cereals** are:

- Maize weevils/rice weevils Sitophilus zeamais, Sitophilus granarius,
- Angoumois grain moth Sitotroga cerealella,
- Lesser grain borer Rhizopertha dominica,
- Larger grain borer Prostephanus truncates.

Pests that feed on milled grain powders and grain dust include:

- Indian meal moth Plodia interpunctella,
- Warehouse beetle Trigoderma variabile,
- Confused flour beetle *Tribolium confusum*,
- Cigarette beetle Lasioderma serricorne,
- Drugstore beetle Stegobium paniceum.

The primary stored grain vertebrate mammalian pests are:

- Common mouse Mus musculus,
- Common and Norway Rats, Rattus rattus and Rattus norvegicus.

Depending upon humidity, some **fungal growth** may also form on damp grain and milled products, increasing aflatoxin risk, and reducing grain quality, in particular Aspergillus species.

Pesticides

Pesticides permitted for use against pests of stored warehouse commodities are detailed in the 12-factor analysis (Section 3.3). Use of these pesticides is only permitted for the crop/pest specified therein and with the specific application conditions stated in the SUAP found in Section 4.

Findings from field visits

Issues with the use of pesticides in stored warehouse commodity protection were identified during visits to program warehouses and during talks with commodity management staff and fumigation service providers (FSP) for the three programs. While many best practices were being correctly followed, it was determined

that there is a general lack of material and human capacity on the part of the fumigation service providers. The equipment being used, the products being applied, and some application practices are considered inadequate by USAID standards and may pose risks to applicators, warehouse managers, and potentially recipients of food aid.

For instance, no gas meters were determined to be in use to monitor gas concentrations over the course of fumigation. Similarly, no respirators are being used. The sprinkling of chlorpyrifos-ethyl (Dursban) dust on the soybean sacks to combat flies could expose workers to the dust when they are moving or transporting the sacks to secondary warehouses. A product containing dichlorvos, named DD Force, was being used as a spot treatment when certain pest outbreaks were detected. This product is not registered or approved by the CSP and is not recommended for use in Title II Commodity Storage Warehouses. Also, uncovered aluminum plates with rat bait containing zinc phosphide are set out to combat rodents. This type of rodenticide application poses potential threats to domestic animals and children and have reduced effectiveness as rats learn to avoid such baits as part of a behavior known as "bait shyness" due to the quick action of the rodenticide.

Location of warehoues

Specifically for warehouse commodity protection, fumigation will occur at the following sites for the different programs.

Catholic Relief Services:

Warehouse	City name	HQ	ROAD	NORTH LAT	EAST LONG
Warehouse 1	Warehouse 1 Maradi Ali Dan sofo		Mohamed vI	13.491.84	7.125.43
Warehouse 2	Maradi	Zarya I	Rue Général Ali Saibou	13.51.167	7.108.22

Mercy Corps:

Warehouse	City name	HQ	ROAD	NORTH LAT	EAST LONG
Warehouse 1	Maradi	Bourja	Route Dan Issa	130 28' 32.6"	70 06′ 46,4′′
Warehouse 2	Zinder	Ja-guindi	Route SONIDEP	130 49' 47,8"	80 06' 46,4''
Warehouse 3	Zinder	Ja-guindi	Route SONIDEP	130 49' 47,8"	80 06' 46,4"

Save the Children:

QUARTIER ZARIA, Coté du Chateau 3 Avenue general Ali Chaibou, Rue ZR2-R088, Maradi

3.2 PESTICIDE REGISTRATION SUMMARY TABLES

The following tables summarize registration of pesticides by their active ingredients that are allowed and not allowed by this PERSUAP.

It can be noted that no herbicides are being recommended by this PERSUAP. This is because there is very limited weed problems in the intervention areas. Even striga can be sufficiently controlled using non-chemical prevention and control methods, such as manual removal.

Programs should complete availability studies of approved pesticides. Even if both Niger and the USEPA have registered a pesticide, this does not guarantee that the product at the correct formulation (CSP-approved product) is readily available.

Table 1a: Approved Pesticides

Approved Active Ingredients with CSP Registered and Authorized Products Available as of November 2014.

See Annex 5 for CSP Registered and Authorized Products as of November 2014.

(Application by GoN-trained and equipped phytosanitary brigade members only; promote farmer use of brigades, rather than self application).

(Only specific products with toxicity Class III or IV can be used on agricultural seeds and growing crops despite some active ingredients having products available with other toxicity classes).

despite some active ingredients having p	. caaca a vandore w	US EPA	
		US EPA	
Active Ingredient	Acute toxicity class	GUP	RUP
	Insecticides/Acaricide	es	
Acetamiprid (May not be used during flowering on crops pollinated by honeybees)	III	Х	
Azadirachtin (Neem oil; also a fungicide)	III	Χ	
Bacillus thuringiensis	III	Χ	
Chloranthraniliprole	IV	X	
Flubendiamide	III	X	
Imidacloprid (May not be used during flowering on crops pollinated by honeybees)	11,111	Х	
Indoxacarb	III	Χ	
Spinosad	IV	Χ	
Spirotetramat	III	Χ	
Thiamethoxam	III	Χ	
F	ungicides/Bactericide	es	
Azoxystrobin	IV	X	
Difenoconazole (Seed treatment only)	III	Х	
Mancozeb	III	Х	
Mefenoxam (Metalaxyl-M)	III	Х	
Thiram	III	Х	

Table 1b: Approved Pesticides with Additional Application Restrictions

Approved Active Ingredients with CSP Registered an Authorized Products Available as of November 2014.

See Annex 5 for CSP Registered and Authorized Products as of November 2014.

(Fumigation and other warehouse commodity protection pesticides must be applied by approved and fully equipped Fumigation Service Providers).

(Acaricides for livestock must be applied by Ministry of Livestock and Animal Husbandry agents). (Application by GoN-trained and equipped phytosanitary brigade members only for any other listed pesticides; promote farmer use of brigades, rather than farmer self application).

(Only specific products with toxicity Class III or IV can be used on agricultural seeds and growing crops despite some active ingredients having products available with other toxicity classes).

Todaets available W	ten dener toxicity classes;					
US EPA						
Acute toxicity clas	Acute toxicity clas GUP					
des/Rodenticides for (Commodity Protection					
1		X				
II		Х				
1	Х					
I	Х					
Acaricides for Livesto	ck					
III	Х					
Application of Ultra Lo	w Volume (ULV) Formulations					
II, III	Х	X				
II	Х					
II, III		Х				
II, III	X					
	Acute toxicity clas ides/Rodenticides for C I II I Acaricides for Livesto III Application of Ultra Lo II, III II	Acute toxicity clas GUP Ides/Rodenticides for Commodity Protection I				

Table 2a: Active Ingredients without CSP Registered and Authorized Products Available as of November 2014.

These active ingredients are approved, but only may be procured, used, or promoted by FFP programs if products with these active ingrdients become registered and authorized by the CSP.

(Application by GoN-trained and equipped phytosanitary brigade members only; promote farmer use of brigades, rather than farmer self application).

(Only specific products with toxicity Class III or IV can be used on agricultural seeds and growing crops despite some active ingredients having products available with other toxicity classes).

US EPA

Active Ingredient	Acute toxicity class	GUP	RUP									
	Insecticides/Acaricides											
Horticultural oil	IV	X										
Methoxy-fenozide	III	X										
Nuclear polyhedrosis virus	III	X										
Pymetrozine	III	X										
Sulfur	III	X										
Tebufenozide	III	X										
	Fungicides/Bactericide	es										
Bacillus subtilis	III	X										
Carboxin (Seed treatment only)	III	X										
Cyazofamid	III	X										
Dicloran	III	X										
Dimethomorph	III	X										
Fluopicolide	III	X										
Fosetyl-aluminum	III	X										
Kresoxim-methyl	III	X										
Metalaxyl	III	X										
Pseudomonas fluorescens	III	X										
Sulfur	III	Х										

Table 2b: Active Ingredients with Additional Application Restrictions without CSP Registered and Authorized Products Available as of November 2014.

These active ingredients are approved, but only may be procured, used, or promoted by FFP programs if products with these active ingrdients become registered and authorized by the CSP.

(Fumigation and other warehouse commodity protection pesticides must be applied by approved and fully equipped Fumigation Service Providers).

(Acaricides for livestock must be applied by Ministry of Livestock and Animal Husbandry agents). (Application by GoN-trained and equipped phytosanitary brigade members only for any other listed pesticides; promote farmer use of brigades, rather than farmer self application).

(Only specific products with toxicity Class III or IV can be used on agricultural seeds and growing crops despite some active ingredients having products available with other toxicity classes).

8								
	US EPA							
Active Ingredient	Acute toxicity clas	GUP	RUP					
	Acaricides for Livestoc	k						
Tetrachlorvinphos	III	X						
Zeta cypermethrin	II, III		Х					
Insecticides/Acaricides for Application of Ultra Low Volume (ULV) Formulations								

	Nige	er			US	SEPA	
Active Ingredient	Registered in Niger by CSP with products available as of Nov 2014	Not registered		Acute toxicity class	GUP	RUP	Not registered o Banned
	Inse	cticides/Acaricio	des	for Crops			
Carbofuran	X			I, II		Х	
Dichlorvos		Х		I, II		Х	
Emamectin benzoate	Х			II, III	х		
Fenitrothion	Х			II, III	х		
Flonicamid		Х		II, III	х		
Lindane (HCH)	Х		1	II			Banned
Profenofos	Х			II	х		
Tebuconazole		Х		II	х		
Tralomethrin	Х			II		Х	
	Fung	icides/Bacterici	des	s for Crops	I		
Captan	X			I, II, III	х		
Carbendazim		Х		III	х		
Copper oxychloride		Х		I, II, II	х		
Difolatan (captafol)		Х		I – IV			Х
Fenhexamid		Х		III	х		
Flusilazole		Х		III			Х
Iprodione	Х			III	х		
Insecticio	des/Herbicides/Re	odenticides for	Wa	rehouse Co	nmodity F	rotection	
Zinc phosphide	X			I		Х	
Glyphosphate	Х			I	х		
Magnesium phosphide		Х		I		Х	
Methyl bromide		Х		I			Banned
Carbon dioxide		Х		II	х		
Bormethaline		Х		II	х		
Difenacoum		Х		III		Х	
Difethialone		Х		I-III	х		
Warfarin		Х		II	х		
		Acaricides for L	ive	stock	•		•
Amitraz		Х		III	х		
Avermectin (Ivermectin, etc. for formulation up to 1.9%)		Х		III	х		
Lindane (HCH, gamma BHC)	Х			II			Banned
		Avicides	s				
Fenthion	X			II			х

The following pesticides are for rain-fed, staple, or cash crop production improvement (Table 4).

Table 4: Pesticides for Rain-fed, Staple, or Cash Crops (Application by GoN-trained and equipped phytosanitary brigade members only). **Insecticides** Acetamiprid (May not be Azadirachtin (Neem oil; used during flowering on Bacillus thuringiensis Chloranthraniliprole crops pollinated by also a fungicide) honeybees) Imidacloprid (May not be used during flowering on Flubendiamide Horticultural oil Indoxacarb crops pollinated by honeybees) Nuclear polyhedrosis Methoxy-fenozide Spinosad Pymetrozine virus Thiamethoxam (May not be used during flowering Tebufenozide Spirotetramat on crops pollinated by honeybees) Only for application in ULV formulations Deltamethrin (Only non-RUP Beta cypermethrin Dimethoate Lambda cyhalothrin products) Malathion **Fungicides/Bactericides** Difenoconazole (Seed

The following pesticides are for other vegetable production improvement (Table 5).

Bacillus subtilis

Fluopicolide

fluorescens

Pseudomonas

Azoxystrobin

Metalaxyl

Dimethomorph

Table 5: Pesticides Approved for Other Vegetable Production
(Application by GoN-trained and equipped phytosanitary brigade members only).
Insecticides

Sulfur

Carboxin (Seed treatment only)

Fosetyl-aluminum

treatment only)

Mancozeb

Thiram

Azadirachtin (Neem oil; also a fungicide)	Bacillus thuringiensis	Chloran	thraniliprole	Horticultural oil	
Imidacloprid (May not be used during flowering on	Indoxacarb	Methox	oxy-fenozide Nuclear		
crops pollinated by honeybees)	IIIdoxacarb	IVIETIO	y-teriozide	polyhedrosis virus	
Pymetrozine	Spinosad	Spirote	tramat	Sulfur	
	Thiamethoxam				
	May not be used				
Tebufenozide	during flowering on				
	crops pollinated by				
	honeybees)				
Fungicides/bactericides					
Azoxystrobin	Cyazofamid		Dicloran	Difenoconazole (Seed treatment only)	
Dimethomorph	Fluopicolide		Fosetyl-aluminum	Kresoxim-methyl	
Mancozeb	Mefenoxam (meta	laxyl-M)	Sulfur	Thiram	

3.3 PER, 12-FACTOR ANALYSIS

Due to the separate pest management needs and the four classes of proposed pesticide uses, there are specific conditions for the use of permitted pesticides that are approved in this PERSUAP.

Section 3.1 explains these four classes in more detail:

- Rain-fed, staple, and cash-crop improved production;
- Vegetable and fodder (and cotton) production improvement, IPM and pesticide safer use training;
- Livestock health and sanitation; and
- Warehouse commodity protection.

For the following "PER" and "SUAP" sections of this PERSUAP, the first two classes will be combined – i.e., Rain-fed, staple, or cash crop improved production; and Vegetable and fodder production IPM and pesticide safer use training.

Special attention has been given to warehouse commodity protection activity due to its importance to the overarching goal of Title II food security programs, and its reliance on RUP pesticides. The analysis specific to Title II commodity protection pesticide use, is included in the 'Commodity Protection' sub-sections of the factors of analysis, below, tiers off of the USAID Programmatic Environemtnal Assessment (PEA) for Phosphine Fumigation of Stored Agricultural Commodity, which has been referenced throughout the PERSUAP.

a) USEPA registration status of the proposed pesticides.

In **Tables 1, 2 and, 3**, above, the pesticides to control plant diseases, insects, mites, and rodents are listed along with their registration according to the United States Environmental Protection Agency (USEPA) and

the CSP, where relevant. USEPA registers pesticides based on the active ingredients, concentration, and formulation, as general use pesticides (GUP), restricted use pesticides (RUP), non-registered or banned pesticides. In Niger, for the purposes of this PERSUAP, the active ingredients are flagged as those with registered approved products and those without. In Annex 5, there is a partial list of CSP approved products and a link that goes to the complete list.

PERSUAP approval of pesticides only applies to individual products that are approved by the CSP for use in CILSS member countries. Not all commercial products that contain an approved active ingredient (AI) are currently approved by the CSP. It is the responsibility of each program to be up-to-date about the latest list of CSP-approved products. The list is updated twice per year to incorporate any changes in registration status. The programs should verify registration information with the DGPV and through the CSP Database (http://196.200.57.138/dbinsah/index.cfm?sect1=pesticide§2=x&id=58), before any activity involving support of pesticides. Additionally, products that contain multiple AIs are only eligible for use if each of the AIs is approved in the PERSUAP.

There are a number of pesticides approved by this PERSUAP that are not currently registered with the CSP or do not have any products that are currently approved. For these pesticides to be eligible for use in practice by the programs, the programs should work to have these Als or products approved by the CSP. The registration process is structurally lengthy, and without guarantee of approval, but diversification of the types of products available in Niger would have broad benefits for program agricultural activities and safer pesticide use in the agricultural sector in general. These pesticides, which are generally newer and more specifically targetted, are encouraged because they may fit a role that reduces the overuse and overreliance on a small number of broad-spectrum pesticides, which is likely to result in the development of pest resistance to pesticides. The programs are advised to lobby and/or collaborate with agrochemical companies and suppliers to homologate products with safer, more specific-use Als.

Commodity protection

This PERSUAP adheres to the USAID Fumigation Programmatic Environmental Assessment (PEA) available at: http://www.usaidgems.org/fumigationpea.htm. All FFP partners must be familiar with the PEA and tools.

Aluminum Phosphide – Fumigation: Aluminum phosphide is an inorganic phosphide registered in the U.S under CAS Number 20859-73-8 with U.S. EPA PC Code 066501. *Aluminum phosphide* is registered by the USEPA as a Restricted Use Pesticide (RUP), so per USAID's Pesticide Procedures it may only be purchased and used only by certified applicators. It is in EPA's toxicity Class I, and all aluminum phosphide products must bear the signal word DANGER. In contact with moisture, it produces a toxic gas *hydrogen phosphide*. *Aluminum phosphide* is widely used for fumigation of food commodities and structures.

This PERSUAP requests use of aluminum phosphide in both pellet and tablet formulations with 55-57% active ingredient. Its use will be restricted to application only by contracted fumigation service providers with proper application and safety equipment.

Warehouse walls and pallets treatments: In addition to the use of aluminum phosphide, warehouse surfaces (floors and walls) may need to be treated in preparation for arrival of commodities. For these treatments, EPA and Niger registered organophosphates, chloropyrifos-ethyl, and pirimiphos-methyl are proposed for

use. Chloropyrifos-ethyl is USEPA registered as an RUP, and pirimiphos-methyl is a GUP. Given the context of warehouse application, both are restricted to application only by contracted fumigation service providers with proper application and safety equipment.

Rodent treatments: Rats are a potential problem in the warehouse where soybean meal is stored. Of the following anticoagulant rodenticides considered: brodifacoum, bormethaline, difenacoum, difethialone, warfarin; **ONLY brodifacoum, is approved by the USEPA and CSP and may be used in programs'** warehouses. Brodifacoum is to be applied using locked and placarded bait boxes, and will only be applied by the contracted fumigation service providers.

Herbicides: Due to the context of the programs' warehouses, in Maradi and Zinder, it is uneconomical to use herbicides for sanitation to control weeds—where rodents hide—around the warehouse perimeter. Manual control, if needed, should be sufficient. At the beginning of the rainy season, managers should use a flat bladed hoe to suppress weeds as they appear. The herbicide generally accepted for this use, glyphosate, is rejected by this PERSUAP for this reason because it is viewed as unnecessary to be promoted.

b) Basis for selection of the pesticides

Registered and intended use: As described in Section 3.1, the PERSUAP covers the use of pesticides under four different classes and contexts: 1) warehouse commodity protection, 2) livestock health and sanitation, 3) direct support of production of rain-fed, staple, and cash crops, and 4) support of off-season vegetable and fodder (and cotton) production through training, including training on IPM and safer use of pesticides. In all cases, pesticides were selected based on their USEPA registered use and based on the recommended pests, crops or commodities on which these pesticides are used in various states in the US.

All pesticides were selected based upon their reported effectiveness for the determined pest management needs (see Factor F and Annex 1).

Toxicity: Furthermore, pesticides for each class were selected based on their toxicity, the application context, and the *capacity of the intended applicators* in terms of access and use of proper application and safety equipment to mitigate toxicity to humans and ecosystems (see Factor D and E).

Local availability: Access was also an important consideration for the selection of pesticides. A significant number of the approved pesticides are neither currently registered in Niger, nor have they been determined to be available. While the availability of currently registered products may vary significantly over the lives of the programs, the current lack of availability and registration of ideal (less-toxic, more specifically targetted) products is a major concern. This concern prompted the approval of these products in this PERSUAP with the condition that they may not be promoted by the programs before they are either registered or available in CSP-approved formulations (see Factor A).

For these pesticides to be eligible for use, the programs must work to have CSP-approved products imported and made accessible locally. Programs are highly recommended to lobby agrochemical suppliers to import homologated products to increase the availability of specific-pest-targeted, legal products to farmers. Due to the presence of CSP-registered pesticides with commercial formulations that are not CSP-approved, suppliers

are familiar with the chemical and its' use, and may already be able to import products type that are approved. The programs should lobby suppliers to offer these approved products from reliable distributors.

Price: Currently, farmers greatly prefer pesticides that are generic and are relatively inexpensive compared to newer pesticides under patent protection. Thus the variety of pesticides that farmers can buy from local agricultural input vendors is very limited. To improve the local availability and the incentive for farmers to use regulated, approved pesticides, the programs must work with the departmental DGPV offices to provide an economically viable alternative to unregulated, generic pesticides.

Rain-fed, staple, or cash crop improved production; and Vegetable and fodder production, IPM and safer use training

Only pesticides in USEPA Toxicity Class III or IV and those classified as General Use Pesticides (GUP) were considered appropriate for this context, as they are the least toxic to applicators. While some approved pesticides do have product formulations that are Class II, only product formulations that are Class III or IV are permitted for use.

Livestock health and sanitation

For livestock protection pesticide application **ONLY** GoN agricultural extension services will be contracted directly to carry out any and all program-related applications. Pesticides selected as approved were thoughtfully considered based on applicator capacity.

Commodity protection

If used in accordance with safeguards, aluminum phosphide is not expected to have adverse environmental impacts. Efficacy and the effectiveness of use safeguards have already been assessed extensively in the USAID Fumigation PEA and thus are not addressed further here. The fumigation PEA is available at: http://www.usaidgems.org/fumigationpea.htm.

The selection was also based on the availability of a qualified professional service provider for phosphine fumigation (see Factor K for recommendation for ensuring FSP access to required fumigation equipment and improving capacity to meet USAID fumigation requirements). Stored commodity protection with pesticides will only be undertaken by certified professional service providers who have complied with the requirements listed in other sections of this PERSUAP.

Contact pesticides and rodenticide approved for commodity protection are also approved with condition that they are applied only by the professional service provider and thus are not expected to have adverse environmental impacts.

c) Extent to which the proposed pesticide use is, or could be, part of an IPM program.

Pesticide support through the programs' agriculture sector activities should be governed by IPM plans provided provided in this PERSUAP according to crop, pest, and control measure; see Annex 1. These IPM plans are intended to serve as the basis for IPM by agricultural crop improved production and training activities, as well as livestock health and sanitation activities, that should be refined and built upon by the implementing partners.

The current state of IPM awareness and farmer education does not support the more sophisticated forms of IPM. Pest management plans will necessarily be at a level of technical complexity appropriate to the local context, but will embody core IPM principles: emphasis on use of non-chemical controls, with need-based, targeted use of relatively less-toxic pesticides.

Programs will often have far less than full control over the actions of beneficiaries in the field. For this reason, programs will promote and support IPM to the greatest practicable extent.

Commodity protection

The Safer Use Action Plan requires compliance with the Fumigation PEA's Annex T-6 "IPM Practices & Inspection Checklist for Commodities and Warehouses." Available at:

http://www.usaidgems.org/Documents/FumigationPEA/FumigPEAToolAnnexes Dec%202013.pdf. This is the checklist contained in the Food for Peace Commodity Reference Guide modified to implement key good-housekeeping based Integrated Pest Management (IPM) practices that are essential complements to fumigation, including daily sanitation of the warehouse, clearing warehouse surroundings of weeds on a weekly basis, daily inspections for pests, and strictly adhering to the first in first out (FIFO) rule to minimize the storage time of the commodities in the warehouse (see SUAP Section 4, Annex 1, and Annex 2).

d) Proposed method or methods of application, including the availability of application and safety equipment.

Note: for all pesticide use, regardless of the applying party, the product label application instructions must be followed.

Rain-fed, staple, or cash crop improved production; and Vegetable and fodder production, IPM and pesticide safer use training

Pesticide usage was found to be relatively low among farmers in Niger. Application, however, is prophylactic (curative in nature) and no structured crop monitoring occurs. The main concern of farmer application is the often complete lack of appropriate application or safety equipment coupled with the widespread use of unregistered, potentially adulterated products. If farmers use any purposeful equipment at all instead of the common practice of applying with a bucket and handheld broom, they will mostly use inexpensive plastic sprayers that do not seal the sprayer tank contents during operation. Leaking pesticide solution wetting the farmer's shirt forms a wick where pesticides are continually absorbed into the skin and subsequently enter the blood stream. In this context, farmers are best-off applying pesticides in much the same way as they do for micro-dosing fertilizer. For example, using one liter hand sprayers to spray the heads of millet and sorghum to control the many pests that attack at the growth-stage could increase pesticide efficiency. Smaller, targeted application, of specific pesticides for specific pest control is central to an IPM program.

Farmers' current use of PPE in the program areas is severly inadequate, and they often lack the knowledge of the hazards to human health when using pesticides. There is little impetus to purchase PPE even if affordable. Training farmers on safer pesticide use, including the need for PPE, is no guarantee that they will adopt improved practices.

For this reason, the program will promote farmers hiring their local brigades at a subsidized rate. These brigades are equipped by the government with PPE (see Photo 1) including a pesticide suit of a top and pants made of lightweight water repellent material. There is also a hood-like cap, rubber boots, goggles or plastic face shield, rubber gloves, and a respirator. The sprayers, which are for both water-based and oil-based formulations is a plastic hand lever pump with 10-liter capacity. The brigades also have battery powered ULV spinning disc sprayers.

The existing agricultural extension infrastructure for pest management, including the purchase and storage of pesticides at the department level by the DGPV, and the local capacity of DGPV field agents and brigades to assess pest management needs, handle, mix, apply, and dispose of pesticides with the proper application and safety equipment, represents the best current solution to the challenges of safe and effective pesticide use at the local level.

Thus, the PERSUAP recommends and the programs have committed to reinforcing and strengthening the services of the GoN-trained and epuipped phytosanitary brigades by promoting buy-in by farmers. Agriculture sector activities should sensitize farmers to the proper use of pesticides, the risks of buying blackmarket products, and the advantages of accessing extension services. The PERSUAP also requires that programs use the brigade services for any direct promotion of pesticides for application to rain-fed-, staple-, or cash-crop (or other vegetable or fodder or cotton) production.

Further increase of acess by farmers to extension services may require the development of cost-support programs as discussed in Section 3.1. Such activities would help improve the accessibility of safer products, as well as improve the practices of the extension services (improvement of disposal system for pesticide containers was determined as a need).

Seed treatment:

Seed treatment is an important and effective preventative measure against potential fungal pests of both rain-fed staple crops and other vegetable productions. Seed treatments are used to control three types of disease, including: fungal smuts, bunts, and root rots, as well as fungal or microbial seedling diseases and insect seed scavengers. Most seed treatment products are made to target one of these types of threats. Therefore, it is very important that the correct product is chosen, taking into account disease history in the area. The Crop, Livestock, and Commodity IPM Plans in Annex 1 should be consulted in deciding which product will be most effective for particular crops and target diseases. Agricultural extentionists' guidance on use of PERSUAP approved products should be followed as these trained agents have the advantage of historical weed, disease, and pest prevalence, and management constraints under local conditions in the intervention area. The degree of control will vary with product, application rate, environmental conditions, and diseases present.

Seed treatments are applied as a dust, a slurry, or a liquid. Liquid and slurry formulations are most effective in coating the seed while dust formulations may not be evenly distributed over the seed's surface due to lack of moisture. Careful measurement and mixing are required to ensure that the appropriate amounts of liquid and slurry treatments are applied. Seed treatment devices typically consist of a mixing tank, a treater head, and a coating chamber. In order to insure correct measurements, application and measuring equipment should be frequently cleaned and calibrated. Some dust treatments are designed to be added to seeds in a

planter box and mixed with a stick. However, like other dust applications, this method does not guarantee even distribution of the treatment.

Personal protection equipment must be worn when handling chemical treatments, as well as chemically treated seed. The label directions corresponding to products used must be followed closely to avoid health risks and environmental damage. Overtreatment may also damage the seed and reduce effectiveness of disease control.

Treated seed should never be used for food or feed and should be kept separate from seeds intended for consumption. All treated seed should be brightly dyed and be labeled as "Not for human or animal consumption." Containers used for seed treatment should be triple rinsed with water. The containers should then be punctured and disposed of in a manner compliant with the Safer Use Action Plan (SUAP) of this analysis. This PERSUAP requires that for all other field uses, only GoN-trained and epuipped phytosanitary brigade members should be directly-supported, using program funds, to apply seed treatments.



Photo 1. Phytosanitary Brigade PPE

Livestock health and sanitation

If non-chemical controls (see Annex 1) are not sufficient to prevent acarian pest outbreaks on livestock, control with acaricides is effective. Acaricide application is the most widely used and effective method of ecotoparasite control, but acaricides should not be used if pest numbers are not large. When needed, treatment should always be carried out twice, the first time to kill the pests currently on the body, the second, 14 days later to kill pests hatching from eggs present at first treatment. Eggs are not affected by acaricides. If a pest outbreak on one individual animal within a herd, then all must be treated or the problem will keep reoccurring.

As required by this PERSUAP, only trained agents of the Ministry of Livestock and Animal Husbandry will apply acaracides to animals or their premeses using the pesticides approved for each application method. The government ministry is equipped with the proper application and safety equipment and must follow all label requirements.

Knapsack Spraying of Livestock:

Hand spraying using knapsack sprayers is the most commonly used method of applying acaricides. It is effective especially if a small number of animals are to be treated. If a sprayer is not available, then the pesticide can be applied with a paintbrush. During spraying, goats and sheep should be tied securely and the entire animal should be sprayed by following this strict sequence: spray along the entire length of the back, spray the sides and flanks in a zigzag pattern, spray the brisket, spray each leg, spray the belly, udder or scrotum, spray the tail and anal area, finally spray the head, head, face, neck, and ears.

- Permethrin 0.25% is labeled for goats, sheep
- Permethrin 10% is labeled for goats, sheep, poultry
- Tetrachlorvinghos: wettable powder concentrate is labeled for direct use on cattle, and poultry

Knapsack Spraying of Chicken Coupes:

If chickens are kept on sand floors, the floors can be sprayed. This is to protect the chickens from the soft tick. Also goat and sheep pens should be sprayed when ecotoparasites are found.

- Permethrin 10%: poultry houses (poultry rate is 3.8 liters/100 birds)
- Tetrachlorvinphos: premises spray or for direct use on poultry

Dust bath:

This is a common application method for poultry and sheep and goats. While wearing a respirator and with the help of another person to hold the bird, dust underneath the wings and vent area of each bird sparingly but thoroughly. For goats and sheep, instructions state to apply up to 2 ounces (6 tablespoons) of dust per animal evenly into the hair over the head, ears, neck, shoulders, back, and tail. For ear ticks, apply approximately 1/3 ounce (1 tablespoon) inside each ear. Repeat as necessary, but do not use more often than once in 3 days.

• Zeta cypermethrin 0.075%: is labeled for goats, sheep

Commodity protection

Aluminum phosphide will be used for indoor fumigation of warehoused food commodities in sheeted stacks only. Via the Fumigation Management Plan, the SUAP requires that fumigation follow acceptable technical practices specified in Annex T-7 of the Fumigation PEA. These include, among others, use of appropriate personal protection equipment, including respirators, maintenance of an exclusion zone that only fumigation personnel can enter for duration of the fumigation (7-10 days or more), and phosphine gas monitoring for efficacy and hazard. The Fumigation PEA can be accessed at: http://www.usaidgems.org/fumigationpea.htm.

Niger FFP partners should also become familiar with the resources available in the USAID/TOPS Warehouse Safety Guide: http://www.fsnnetwork.org/warehouse-staff-safety-guide.

The supplementary contact pesticides: chlorpyriphos-ethyl and pirimiphos-methyl, will also be applied by the contracted fumigation service provider following the guidelines laid out in the PEA or according to their toxicity level.

Spray Contact Insecticides:

Spray the empty warehouse (floor, walls, roofs, etc.) and surrounding areas before receipt of food commodities to kill any live insets. The perimeter of the warehouse on the outside should be sprayed, as described below. The aim is to kill insects before fumigation and to to kill those pests that might escape the fumigation. Evacuate the warehouse prior to spraying Aerate the warehouse after 12 hours wearing a carbon-filter or canister-filter mask.

For wall, floor, ceiling, and pallet spraying, the following PPE must be used: Respiratory breathing protection for mouth/nose: canister-filter gas masks for phosphine concentrations of 0.3-15 ppm; carbon-filter mask. For the remainder of the body: chemical resistant rubber gloves, overalls or long sleeves and pants, rubber boots, goggles.

Anticoagulant rodenticides:

Use bait blocks of brodifacoum (vertox pellets) rodenticide in locked, chained and placarded bait boxes, only (never put bait blocks in the open in the warehouse). Only to be applied by the contracted fumigation service provider. PPE for handling rodenticide bait blocks, use: Chemical resistant rubber gloves.

e) Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use, and measures available to minimize such hazards.

The following tables detail the acute and long-term toxicological hazards associated with the proposed use of the pesticides analyized for this PERSUAP.

Table 6 Pesticide Human Toxicity Profiles

				, ity i i 0iii			•			
Common	Carcinogen	Mutagen	Teratogenic	Endocrine disrupter	Reproductive development effects	Acetyl cholin- esterase inhibitor	Neuro- toxicant	Respiratory tract irritant	Skin irritant	Eye irritant
Pesticides	for Cro	ops								
				Insecticid	es/acaricide	S				
Acetamiprid (May not be used during flowering on crops pollinated by honeybees)	x	х	-	?	-	x	x	x	x	х
Azadirachtin (Neem oil; also a fungicide)	х	х	х	Suspected	х	х	х	х	х	Moderate
Bacillus thuringiensis	?	-	-	?	?	-	-	-	-	-
Chlorantra- niliprole	х	х	х	х	х	Х	Х	-	х	х
Flubendiamide	Х	Х	Х	-	?	X	X	Х	Х	X
Horticultural oil Imidacloprid (May not be used during flowering on crops pollinated by honeybees)	x	x	x	- X	x	×	?	x	x	Moderate x
Indoxacarb	х	Х	х	х	х	х	✓	Х	Х	Moderate
Methoxy- fenozide	Х	х	х	?	Х	х	х	=	х	х
Nuclear polyhedrosis virus	?	-	-	?	?	-	-	-	-	-
Pymetrozine	?	Х	Х	х	✓	х	-	Х	Х	х
Spinosad	х	Х	Х	х	?	Х	Х	Х	Х	х
Spirotetramat	х	Х	Х	-	?	х	Х	-	Х	✓
Sulfur	Х	?	Х	х	Х	Х	Х	Х	х	✓
Tebufenozide	X	X	Х	-	X	Х	-	-	X	X
Thiamethoxam (May not be used during flowering on crops pollinated by honeybees)	Possible	-	X	?	Minor	-	x	Mild	Mild	✓
					s/bactericide				/	
Azoxystrobin	X	-	-	?	?	Х	Х	-	√	Х
Bacillus subtilis Carboxin (Seed	? x	-	-	?	?	- X	-	-	- X	- ✓
treatment only) Cyazofamid	Х	х	-	-	?	Х	Х	Х	✓	✓
Dicloran	Х	Х	Х	-	✓	х	?	✓	Х	Х
Difenoconazole (Seed treatment only)	Possible	х	х	Suspected	?	-	-	-	Mild	Mild
Dimethomorph	х	х	-	-	х	х	х	✓	x	✓
Fluopicolide	Х	-	-	-	Х	Х	Х	х	Х	Moderate

Fosetyl- aluminum		х	х	-	х	?	?	✓	х	✓
Kresoxim- methyl	?	-	-	-	х	х	х	✓	✓	✓
Mancozeb	✓	?	?	-	Х	Х	х	✓	✓	✓
Mefenoxam (Metalaxyl-M)	x	х	?	-	x	x	х	х	✓	✓
Metalaxyl	Х	х	Х	-	Х	х	х	✓	✓	Turns red
Pseudomonas fluorescens	?	-	-	?	?	-	-	-		-
Sulfur	Х	?	Х	х	Х	Х	х	Х	Х	✓
Thiram	Х	?	Х	x	✓	Х	✓	Х	Slight	Moderate

Pesticides with Additional Application Restrictions

	F	umigants/	Insecticid	es/Rodenticide	s for Wareh	ouse Commo	dity Prote	ection		
Aluminum Phosphide	-	х		-	?	x	-	?	х	?
Chlorpyriphos- ethyl	х	х	х	Suspected	✓	✓	✓	х	✓	✓
Pirimiphos methyl	х	-		-	-	✓	-	✓	✓	?
Brodifacoum	Х	-		Х	Х	Х	Х	X	?	?
				Acaracides	for Livesto	ck				-
Permethrin (Also permitted for use in warehouses)	?	х	х	*	✓	?	✓	-	✓	√
Tetrachlorvinph os	х	х	х	х	-	✓	✓	-	х	x
Zeta cypermethrin	х	х	х	Suspected	?	х	х	✓	✓	✓
• •	•	Insectici	des/acario	cides/fungicides	s for applica	tion of ULV	ormulatio	ns		•
Beta cypermethrin	х	-		?	-	х	х	х	х	х
Deltamethrin (Only non-RUP products)	х	х	х	Suspected	х	х	✓	х	х	х
Dimethoate	?	?	?	?	✓	✓	х	-	Х	✓
Lambda cyhalothrin	х	?	х	?	х	х	-	✓	х	Moderate
Malathion	?	?	?	?	?	✓	✓	?	Х	х

Disallowed Pesticides

			Inse	ecticides/a	caricides f	or crops				
Carbofuran	Х	Х	х	✓	✓	?	?	х	х	х
Dichlorvos	Probable ?	х	х	?	-	✓	✓	?	✓	✓
Emamectin benzoate	х	х	?	-	?	-	х	?	х	х
Fenitrothion	Х	Х	Х	✓	-	✓	Х	-	✓	Х
Flonicamid	?	Х	Х	-	?	Х	Х	Х	Х	Х
Lindane	✓	Х	Х	\checkmark	?	ı	✓	?	✓	✓
Profenofos	х	Х	Х	?	?	✓	✓	-	✓	Х
Tebuconazole	?	-		-	х	Х	Х	Х	Х	✓
Tralomethrin	х	Х	Х	?	?	Х	✓	Х	Х	Х
			F	ungicides/ba	ctericides for	crops				
Captan	✓	х		Х	-	х	х	-	✓	✓ Rated tox cat I
Carbendazim	?	-	-	-	✓	Х	Х	х	Х	х

Difolatan (captafol)	✓	х	х	-	х	x	х	✓	✓	✓
Fenhexamid	Х	-	-	-	Х	Х	Х	Х	Х	moderate
Flusilazole	✓	х	-	-	✓	х	х	?	х	x
Iprodione	✓	-	Х	-	Х	х	х	✓	✓	✓
Copper oxychloride	-	-	-	-	-	х	-	?	✓	✓
		Insecticide	es/herbicid	es/rodenticide	s for wareho	use commo	dity proted	ction		
Zinc phosphide	Х	-		-	\checkmark	?	-	-	х	x
Glyphosate	Х	х		-	Х	Х	х	Х	✓	✓
Magnesium phosphide	х	-		-	?	х	х	✓	х	?
Methyl bromide	-	Х		-	?	Х	-	?	Х	?
Carbon dioxide	Х	х	х	x	Х	Х	х	х	х	x
Bromethalin	х	-		x	-	х	✓	-	√	√
Difenacoum	-	-		-	✓	Х	-	х	х	Х
Difethialone	-	-		-	✓	Х	-	х	х	Х
Warfarin	-	-		-	✓	Х	-	х	х	Х
		•		Acaricides	for livestoe	k				-
Amitraz	?	Х	?	?	?	-	✓	Х	х	х
Avermectin	Х	Х	Х	Suspected	✓	Х	?	-	✓	Moderate
Lindane	✓	Х	Х	✓	?	-	✓	?	✓	✓
	•			Av	icides					
Fenthion	?	?	Х	?	x	\checkmark	?	✓	✓	✓

Key

- √: Yes, known to cause a problem,
- x: No, known not to cause a problem,
- ?: Possibly, status not identified,
- -: No or inconclusive data.

There are two systems used to classify the acute toxicity of pesticides: the USEPA and WHO systems. The USEPA system has four levels and is based on the specific formulation of a given product, thus one pesticide active ingredient can have several toxicity levels depending on how it is formulated and concentrated in different products. The different levels are denoted on pesticide labels with a different signal word and color code, as shown in the toxicity profiles table below (Table 8). The WHO system is based on the technical concentration (100% active ingredient) and not on specific formulations of different concentrations. WHO splits the highest toxicity, Level I, into two parts: "Ia" for the extremely toxic and "Ib" for somewhat less toxic than "Ia" pesticides. In measurements of a pesticide active ingredient concentration, one ppm is equal to 1 ml or 1 mm depending on the formulation. The toxicity levels of pesticides include consideration of its effects upon entering the eye or contacting the skin. The more toxic the substance the more irritation and pain and the longer it has such effects.

Table 7: Pesticide Environmental Toxicity Profiles

			Niger	Acute t	oxicity	Envir	onmental	fate				N	lon-targe	t organi	sms			
Active Ingredient	Chemical class	EPA Reg	Reg/ CSP products	WHO	EPA	Mobility in soil & water	Persis- tence	Groun d water	Fish	Bee	Bird	Amphi b-ian	Earth - worm	Mol- lusk	Crus- tacea	Aquati c- invert	Phyto - plank -ton	Zoo- plan- kton
Pesticides fo	r Crops																	
A						1	Insecticio	les										
Acetamiprid (May not be used during flowering on crops pollinated by honeybees)	chloro-nicotinyl	GUP	Y	none	III	High	Moder ate	Poten- tial	NAT	MT	нт	NAT	НТ	MT	PNT	PNT	ST	VHT
Azadirachtin (Neem oil; also a fungicide)	botanical	GUP	Y	Not listed	Ш	Mode- ate	Moder ate	Not detect -ed	ST	MT	ST	MT	PNT	ST	VHT	НТ	PNT	PNT
Bacillus thuringiensis	microbial	GUP	Υ	Not listed	III			No data		PNT		NAT			ST			
Chloranthraniliprole	anthranilic diamide	GUP	Y	Not listed	IV	High	High	Poten- tial	ST	NAT	PNT	ST	PNT	MT	HT	HT	MT	VHT
Flubendiamide	anthranilic diamide	GUP	Y	Not listed	Ш	Low	High	Not detect -ed	PNT	PNT	ST	PNT	PNT	PNT	PNT	PNT	PNT	
Horticultural oil	Petroleum derivative	GUP	N	Not listed	lv	Low	Low		PNT	PNT	PNT	PNT	PNT	PNT	PNT	ST	PNT	ST
Imidacloprid (May not be used during flowering on crops pollinated by honeybees)	chloro-nicotinyl	GUP	Y	II	II & III	Moderat e	Moder ate	Poten- tial	NAT	НТ	VHT	NAT	PNT	PNT	MT	VHT	MT	ST

			Nigor	Acute t	oxicity	Envir	onmental	fate				N	lon-targe	et organi	isms			
Active Ingredient	Chemical class	EPA Reg	Niger Reg/ CSP products	WHO	EPA	Mobility in soil & water	Persis- tence	Groun d water	Fish	Bee	Bird	Amphi b-ian	Earth - worm	Mol- lusk	Crus- tacea	Aquati c- invert	Phyto - plank -ton	Zoo- plan- kton
Indoxacarb	oxadiozine	GUP	Υ	Not listed	III	Low	Moder -ate - High	Not detect -ed	НТ	VHT	HT- PNT	НТ	MT- PNT	нт	НТ	HT	PNT	МТ
Methoxy-fenozide	diaclhydrazine	GUP	N	Not listed	Ш	Moder- ate	High	Poten- tial	MT	ST	ST	MT	PNT	MT	MT	MT	PNT	MT
Nuclear polyhedrosis virus	microbial	GUP	N		Ш													
Pymetrozine	Triazine	GUP	N	Not listed	Ш			potenti al										
Spinosad	macrocyclic lactone	GUP	Y	IV	IV	Low- Moder- ate	High	Not detect ed	ST- MT	НТ	MT	ST-MT	PNT	нт	MT	HT	ST- MT	ST
Spirotetramat	Ketoenol	GUP	Y	Not listed	Ш	Moder- ate	Low	Not detect	ST- MT	PNT	MT	ST-MT	ST	НТ	MT	ST	RNT	ST
Sulfur	Inorganic	GUP	N	U	Ш	ST	Moder ate		ST- NAT	RN T	ST	NAT	PNT		RNT	VHT	VHT	VHT
Tebufenozide	Diacylhydrazine	GUP	N	Not listed	Ш	Low- Medium	High	Poten- tial	MT- HT	PNT	MT	MT-HT	PNT	НТ	MT	MT	PNT- HT	ST- MT
Thiamethoxam (May not be used during flowering on crops pollinated by honeybees)	Neonicotinoid	GUP	Y	Not listed	III				PNT	VHT	PNT		PNT	PNT	PNT	PNT	ST	ST
		ı					Fungicid	es										
Azoxystrobin	strobin	GUP	Υ	U	IV	Low	High	Poten- tial	ST- HT	NAT	PNT	HT	RNT	MT	HT	HT	HT	HT- VHT
Bacillus subtilis	microbial	GUP	N	Not listed	Ш	Low	Low	Not detect ed	ST	NAT	NAT	NAT	PNT	NAT	NAT	NAT	NAT	NAT
Carboxin (Seed treatment only)	Carboxamide	GUP	N	U	III	High	Low	Not detect ed	ST- MT	PNT	PNT	ST-MT	ST- MT	ST- MT	NAT- ST	ST	нт	ST
Cyazofamid	triazole	GUP	N	Not listed	Ш	Low	Low	Not detect ed	НТ	ST	PNT	НТ	RNT	VHT	VHT	VHT	VHT	НТ
Dicloran	Substituted Benzene	GUP	N	U	III	Low	Low	Poten- tial	ST- HT	NAT	ST- PNT		RNT			MT	HT	MT
Difenoconazole (Seed treatment only)	Azole	GUP	Y	III	III				ST	MT	ST		MT		МТ		НТ	HT
Dimethomorph	Morpholine	GUP	N	U	Ш	Moderat e	Moder ate	Poten- tial	ST- MT	PNT	PNT	ST-MT	PNT	MT	MT	HT	MT	ST
Fluopicolide	Benzamide pyridine	GUP	N	Not listed	Ш	Moderat e	High	Poten- tial	HT	ST	PNT		RNT			MT	VHT	MT

			Nigor	Acute t	oxicity	Envir	onmental	fate				١	lon-targe	t organi	isms			
Active Ingredient	Chemical class	EPA Reg	Niger Reg/ CSP products	WHO	EPA	Mobility in soil & water	Persis- tence	Groun d water	Fish	Bee	Bird	Amphi b-ian	Earth - worm	Mol- lusk	Crus- tacea	Aquati c- invert	Phyto - plank -ton	Zoo- plan- kton
Fosetyl-aluminum	phosphonate	GUP	N	Not listed	III	High to moderat e	Low	Poten- tial	NAT	ST	PNT		PNT	MT	MT	MT	MT	МТ
Kresoxim-methyl	Strobilurin	GUP	N	Not listed	III	Moder- ate	low	Poten- tial	ST- HT	ST	ST		RNT	VHT	VHT	VHT	VHT	VHT
Mancozeb	dithiocarbamate	GUP	Υ	U	Ш	Slight	Low	Potent ial	MT- HT	MT	ST	MT-HT	RNT			VHT	NAT	NAT- HT
Mefenoxam (Metalaxyl-M)	Xylylalanine	GUP	Υ	Not listed	III	Low to high	moder ate	Poten- tial	NAT -HT	ST	MT		RNT	MT		RNT	RNT	ST
Metalaxyl	Xylylalanine	GUP	N	Ш	Ш	moderat e	moder ate	Poten- tial	ST- RN T	ST- RN T	MT		RNT- PNT	ST	ST	ST	ST	ST
Pseudomonas fluorescens	Microbial	GUP	N	Not listed	III	Low	Low	Not detect ed	ST	NAT	NAT	NAT	PNT	NAT	NAT	NAT	NAT	NAT
Sulfur	Inorganic	GUP	N	U	III	ST	Moder ate		ST- NAT	RN T	ST	NAT	PNT		RNT	VHT	VHT	VHT
Thiram	Dithio-carbamate	GUP	Y	III	Ш	Low	Low	No data	HT- VHT	PNT	PNT	VHT	RNT	_	NAT- VHT	HT	VHT	HT- VHT

Pesticides with Additional Application Restrictions

				Insectic	ides/Ro	denticides	for Warel	nouse Co	mmodit	y Prote	ection							
Aluminum phosphide	inorganic	RUP	Υ	Not listed	- 1	Low												
Brodifacoum	Coumari	GUP	Υ	IA	III	Low		Insuffi cient	MT		нт					HT		
Chlorpyriphos-ethyl	organo- phosphate	RUP	Υ	II	П	Low	Moder ate- High	Not detec- ted	нт	НТ	VHT	MT	PNT	MT	VHT	HT	PNT- MT	MT
Pirimiphos-methyl	Organo- phosphate	GUP	Υ	Not listed	П			No data	MT	MT								
						Acario	cides for I	ivestock										
Permethrin (Also permitted for use in warehouses)	pyrethroid	GUP	Υ	II	Ш	Not	Low		VHT	ST- HT	PNT	ST- VHT	ST	NAT - VHT	VHT	VHT	ST- VHT	MT- VHT
Tetrachlor-vinphos	Organo- phosphate	GUP	N	U	Ш	Slight	Low		MT- HT	ST	ST	MT	MT	НТ	HT	VHT		VHT
Zeta cypermethrin	pyrethroid	RUP	N	lb	II, III	Low	Low	Not detect	HT	HT	PNT	HT	MT	MT	VHT	VHT	VHT	
	•		•		<u> </u>	Insec	ticides/ac	aricides	·					·	<u> </u>			
Beta cypermethrin	pyrethoid	RUP	N	II	II & III	Low	Low	Not detect	НТ	НТ	PNT	HT	MT	MT	VHT	VHT	VHT	

			Niger	Acute t	oxicity	Envir	onmental t	fate				١	lon-targe	t organi	isms			
Active Ingredient	Chemical class	EPA Reg	Reg/ CSP products	WHO	EPA	Mobility in soil & water	Persis- tence	Groun d water	Fish	Bee	Bird	Amphi b-ian	Earth - worm	Mol- lusk	Crus- tacea	Aquati c- invert	Phyto - plank -ton	Zoo- plan- kton
Deltamethrin (Only non-RUP products)	pyrethoid	RUP /GU P	Υ	П	II & III	Low	Low- Moder ate	Not detect	НТ	MT	ST	VHT	MT	NAT	VHT	VHT	VHT	VHT
Dimethoate	organo- phosphate	GUP	Υ	=	II	High	Low	Poten- tial	ST	VHT	VHT	HT	MT	VHT	HT	VHT	MT	
Lambda cyhalothrin	pyrethroid	RUP	Υ	II	II & III	Low	Moder ate	Not detect -ed	MT	VHT	ST	MT	MT	MT	MT	MT	MT	VHT
Malathion	organo- phosphate	GUP	Y	III	II & III	Moder- ate	Low	Poten- tial	ST- VHT	HT	HT	ST- VHT	ST- MT	PNT VHT	ST- VHT	VHT	HT	PNT- VHT

Disallowed pesticides:

							Insectici	des										
Carbofuran	carbamate	RUP	N	1b	1-11	High	Low	Poten- tial	MT	НТ	VHT	ST	MT	MT	НТ	HT	VHT	VHT
Dichlorvos	organo- phosphate	RUP	N	lb	ı	High	Low	Poten- tial	ST	НТ	VHT	ST	ST	ST	HT	HT		MT
Emamectin benzoate	botanical macrocylic lactone	GUP	Y	Not listed	II & III	Low	Low	Not detect -ed	НТ	НТ	VHT	НТ	МТ	НТ	НТ	VHT	МТ	VHT
Flonicamid	pyridinecarbox- amide	GUP	N	Not listed	 (WG & (SG)	High	Low	Poten- tial	PNT -ST	PNT	PNT -ST	PNT- ST	PNT	PNT	PNT	PNT	ST	
Lindane (HCH)	Organo-chlorine	Ban- ned	Ν	II	=	Moder- ate	High	Poten- tial	ST- VHT	HT	PNT -MT	MT-HT	ST- MT	ST- HT	ST- VHT	HT- VHT	MT	ST- VHT
Profenofos	organo- phosphate	GUP	Y	II	=	Low- slight	Low	Poten- tial	MT- VHT	HT	MT- HT	MT-VH	MT	VHT	VH	HT	НТ	MT- VHT
Tebuconazole	azole	GUP	N	III	Ш			Potent ial	MT									HT
Tralomethrin	pyrethroid	RUP	N	II	Ш	Low	Moder -ate	Not detect ed	VHT	НТ	НТ	VHT			VHT	VHT	VHT	VHT
Fenitrothion	organo- phosphate	GUP	Υ	II	II & III	Low- Moderat e	Low	Not detect -ed	MT	НТ	ST- VHT	MT	МТ	МТ	VHT	НТ	МТ	
							Avicide	s										
Fenthion	organo- phosphate	Not reg	N	II	=	Slightly	Low	Poten- tial	НТ	VHT	VHT	VHT	RNT	MT- VHT	HT- VHT	VHT	МТ	HT- VHT
		•					Fungicio	les	•	•	•	•	•	•				

			Niger	Acute t	oxicity	Envii	onmental	fate				N	lon-targe	t organi	sms			
Active Ingredient	Chemical class	EPA Reg	Reg/ CSP products	WHO	EPA	Mobility in soil & water	Persis- tence	Groun d water	Fish	Bee	Bird	Amphi b-ian	Earth - worm	Mol- lusk	Crus- tacea	Aquati c- invert	Phyto - plank -ton	Zoo- plan- kton
Captan	thiopthalamide	GUP	N	U	I, II, III	Low	Low- moder ate	Not detect ed	HT- VHT	NAT	PNT	MT	нт	ST- MT	NAT- MT	МТ	MT	MT- VHT
Carbendazim	benzimidazole	GUP	N	U	Ш	Low- moderat e	Low	Not detect ed	МТ	NAT	ST	ST	МТ	МТ	ST	НТ	MT- HT	нт
Difolatan (Captafol)	Thiophthalimide	Not reg	N	la	I, IV	Slightly	Low	Not detect ed	НТ	RNT	PNT	MT	RNT	ST- MT	MT	МТ		
Fenhexamid	Anilide	GUP	N		III	Low	Low	Poten- tial	ST- MT	PNT	PNT		RNT	MT	MT	RNT	ST	RNT
Flusilazole	triazole	Not reg	N	III	Ш	Slightly	High		MT	МТ	PNT		RNT				MT	НТ
Iprodione	dicarboximide	GUP	Υ	U	Ш	low	moder ate	Poten- tial	MT	HT	ST		PNT		HT	HT	MT	MT
Copper oxychloride	Inorganic-Copper	GUP	N	III	I, II, III	Low	Very high	Not detect ed	HT- VHT	ST	PNT	HT	нт	VHT	VHT	VHT	HT- VHT	VHT
			Inse	cticides/	herbici	des/rodent	icides for	warehou	se com	modity	protect	ion						
Zinc phosphide	Inorganic	RUP	N	IB	I,III, IV			Potent ial	HT									
Glyphosphate	Phosphonoglycin e	GUP	Y	U	1-111			Insuffi cient	ST	NAT			PNT					
Magnesium phosphide	Inorganic	RUP	N	b	ı			Insuffi cient										
Carbon dioxide	Inorganic	GUP	N	Not listed	11-111			Insuffi cient										
Bromethalin		RUP	N	IA	ı			Insuffi cient	НТ									
Difenacoum	Coumarin	RUP	N	IA	Ш			Insuffi cient										
Difethialone	Coumarin	GUP	N	IA	- 1			Insuffi cient	VHT									
Warafin	Coumarin	GUP	N	IB	II			Insuffi cient	NAT	PNT					NAT			
						Acario	cides for	Livestock										
Amitraz	Formamidine	GUP	N	III	Ш	Slight	Low		ST- HT	ST- HT	ST	ST-MT	RNT		MT- NAT	VHT	ST	ST
Avermectin (Lvermectin, etc.)	botanical, macrocyclic lactone	GUP	N	Not listed	III	Not	Moder ate		VHT	VHT	НТ		ST	RN T	VHT	VHT	МТ	VHT
Lindane (HCH, Gamma BHC)	organo-chlorine	Ban- ned	N	П	Ш	Moder- ate	High	Poten- tial	ST- VHT	HT	PNT -MT	MT-HT	ST- MT	ST- HT	ST- VHT	HT- VHT	MT	ST- VHT

			Niger	Acute t	oxicity	Envir	onmental f	ate				N	lon-targe	t organi	sms			
Active Ingredient	Chemical class	EPA Reg	Reg/ CSP products	WHO	EPA	Mobility in soil & water	Persis- tence	Groun d water	Fish	Bee	Bird	Amphi b-ian	Earth - worm	Mol- lusk	Crus- tacea	Aquati c- invert	Phyto - plank -ton	Zoo- plan- kton

NOTATIONS:

WHO Acute Toxicity (Class Ia = Extremely Hazardous, Ib = Highly Hazardous, II = Moderately Hazardous, II = Slightly Hazardous, U = Unlikely to Present Acute Hazard in Normal Use)

EPA Acute Toxicity Classes (Class I = Extremely Toxic, II = Highly Toxic, II = Moderately Toxic, IV = Slightly Toxic)

Chronic Toxicity (KC=Known Carcinogen; PC=Possible Carcinogen; ED=Endocrine Disruptor potential; RD=Reproductive or Developmental Toxin potential; NT=Neurotoxin)

G-water contaminatnt = Groudnwater contamination risks (known contaminant, no data=potential risk due to uncertainty of data or suggestive evidence of contamination, low risk due to rapid breakdown, low leachability, low toxicity profile, etc.)

Ecotoxicities (VHT=Very Highly Toxic; HT=Highly Toxic; MT=Moderately Toxic; ST=Slightly Toxic; PNT=Practically Not Toxic; NAT=Not Acutely Toxic)

Niger Registration categories: registered active ingredient with currently approved products (Y); no approved products (N).

Up-to-date as of time of review.

Table 8: Toxicity profile	s for USEP	A and WF	IO systems		
USEPA toxi	city classification s	system		WHO s	ystem
Toxicity class	Signal word	Toxicity	Amount to kill an average person	Toxicity class	Hazard
1	DANGER POISON	Higly toxic	Few drops-1 teaspoon	la	Extreme
Ш	WARNING	Moderately toxic	1-6 teaspoons	lb	High
III	CAUTION	Slightly toxic	> 6 teaspoons	II	Moderate
IV	CAUTION	Not toxic	Not applicable	III	Slight
				U	Unlikely

Table 9: U	ISEPA Toxicity	profiles f	or non-targ	et organism	S
		Mam	malian/bird	Aquatic invertebrates/	Honey bee
		LD	₅₀ mg/kg	fish	Acute oral LD 50
Toxicity class	Descriptive term	Oral	Dermal	LC ₅₀ mg/l	μg/bee
1	Very highly toxic	<u><</u> 50	<u><</u> 200	< 0.1	
II	Highly toxic	50-500	200-2,000	0.11-1.0	< 2
III	Moderately toxic	500-5,000	2,000-20,000	1.1-10.0	2.1-11
IV	Slightly toxic	> 5,000	> 20,000	10.1-100	> 11
IV	Relatively non-toxic			101-1,000	
IV	Practically non-toxic			1,001-10,000	
IV	Not toxic			> 10,000	

Commodity protection

The potential toxicological effects of aluminum phosphide are well covered by EXTOXNET, and Extension Toxicology Network.* The Fumigation PEA includes details of acute human health exposure and potential impacts to fumigators, other on-site workers, visitors, nearby residents, and beneficiaries. The Fumigaton PEA can be accessed at: http://www.usaidgems.org/fumigationpea.htm. In summary:

- The main routes of exposure to aluminum phosphide are through inadvertent ingestion or inhalation during fumigation of the highly toxic gas.
- Symptoms of mild to moderate acute aluminum phosphide toxicity include nausea, abdominal pains, tightness in chest, excitement, restlessness, agitation, and chills. Symptoms of more severe toxicity include diarrhea, cyanosis, difficulty breathing, pulmonary edema, respiratory failure, tachycardia and hypotension, dizziness and or death.
- The available evidence for reproductive effects in animals suggests that they are not likely in humans under normal conditions. No evidence is available to support teratogenic effects in humans or to support the ability of aluminum phosphide to cause mutations or increase mutation rates.
- There is no evidence of aluminum phosphide having a negative impact on soil or ground water. It breaks down spontaneously in the presence of water to form a gaseous product, thus is non-persistent and non-mobile in soil and poses no risk to groundwater. For the same reasons, it is unlikely that aluminum phosphide or phosphine will contaminate surface waters.
- The USEPA has determined that uses of aluminum phosphide will not generally cause unreasonable adverse effects to humans or the environment if used in accordance with the approved use directions and revised precautionary statements prescribed by the registration standard. Requirements for acute toxicity data have been waived because of the well-known extreme inhalation toxicity of phosphine gas, which it generates. Accordingly, aluminum phosphide has been placed in toxicity category I, the highest toxicity category. Tolerances have been established for raw agricultural commodities at a level of 0.1 ppm (40 CFR 180.225); processed foods 0.01 ppm (21 CFR 193.20); and animal feeds 0.1 ppm (40 CFR 561.40). Finished food and feed must be held and aerated 48 hours prior to being offered to the consumer.

Measures available to minimize hazards

Rain-fed, staple, or cash crop improved production; and Vegetable and fodder production, IPM and pesticide safer use training

While some of the recommended pesticides do have chronic toxicity concerns, such as being carcinogenic or potentially disruptive to endocrine systems. Pesticide use among small-scale farmers in Niger, is generally small, asynchronous or with infrequent applications. For this reason, as opposed to in large crop production settings, toxicity levels causing chronic health and environmental effects are not likely to be realized. Small-scale, staggered applications will not accumulate greatly in field runoff of contaminated water or soil. Emphasizing adoption of IPM programs will further reduce pesticide applications and their build up in humans and the environment. Avoiding development of pesticide resistance in pests will dramatically reduce the necessity of frequent pesticide applications and provide a critical step in mitigating acute and chronic hazards of pesticides. Educating farmers on transferring pesticide usage to the safest pesticides, which are

typically newer formulations and are for specific uses as opposed to the more toxic, broad-spectrum products, is another long-term risk reduction strategy.

Among pesticides approved for use on crops, acute toxicity risks to applicators and farmers will be mitigated by the use of pesticides in the safest two toxicity categories (Toxicity Classes III and IV) and with the requirement that only GoN-trained and epuipped phytosanitary brigade members apply pesticides for program associated agriculture activities. Among pesticides for field use with additional application restrictions (government ULV spraying for migratory pests or specific uses) risk is mitigated through the requirement that certified and trained applicators are equipped with the necessary application and safety equipment to handle these more toxic chemicals, as well as the requirement that program-contracted ULV sprays be performed by ULV-hand sprayers only, and on the smallest scale possible.

Livestock health and sanitation

In the case of livestock, pesticides will only be applied as a last case scenario, if a pest outbreak has reached the determined action-threshold despite non-chemical best efforts. Only Ministry of Livestock and Animal Husbandry agents with proper application and safety equipment will apply products (see Factor D).

Commodity protection

Via the Fumigation Management Plan, the SUAP requires that fumigation follow acceptable technical practices specified in Annex T-7 of the Fumigation PEA (http://www.usaidgems.org/fumigationpea.htm). These include, among others, use of appropriate personal protection equipment, including approved respirators, maintenance of an exclusion zone that only fumigation personnel can enter for duration of the fumigation (7-10 days or more), the use of gas impermeable tarps, and phosphine gas monitoring.

For all pesticide uses, see Factor D, for application and safety material and equipment requirements, as well as the Environmental Mitigation and Monitoring Plan (EMMP), and SUAP requirements.

f) Effectiveness of the requested pesticides for the proposed use.

Pest management needs are documented on a crop-by-crop basis in Annex I. For each crop, the IPM plans in Annex I identify pest-specific chemical controls (pesticides). Three different sources of data have been used to specify these proposed uses. While none of the pesticides are perfect individually, together with an IPM strategy, they offer a high degree of assurance that the pesticides will be effective for their proposed use.

- The proposed pesticide uses are consistent with their EPA registrations; in each case, USEPA has registered these pesticides for use on the same or similar crops and against the same or similar pests. Such registration requires that the effectiveness of the pesticides be demonstrated. Admittedly, this demonstration of effectiveness is within the US agro-environmental context.
- Each of the recommended uses has been cross-checked against information provided by the pesticide labels, and the registration and label information was supplemented with published literature or recommendations available from other countries, as well as from the Internet.
- All of the recommended practices given in this PERSUAP were taken from results of scientific studies on each crop or a very similar crop and for each pest or very similar pest. Because of the particular climate of Niger, however, some of the pesticides may not perform as expected, which may require retailing the IPM plans to the specific identified gaps and needs.

On-farm verification trials to test recommended practices are not currently being done substantially by the DGPV, but should be promoted by the programs. Given the climate and soil conditions of Niger it is not expected that chemical and non-chemical technologies developed in other countries will transfer directly to Niger. Without a testing program, these discrepancies cannot be documented. There is a testing program to register each new pesticide that involves field trials, but many of these are carried out on experiment stations. There is no requirement in the registration process to verify if each given pesticide will control the many pests associated with each crop rather than just a few main ones. These trials may only be carried out on a selected cereal and vegetable crop so there is a large gap in knowledge concerning other crops and pests. Potential impact of pests may differ each year so on-farm trials to determine product effectiveness for each of the expected pests on a given crop is a lengthy process.

In general, development of resistance is a key threat to pesticide effectiveness. Due to the fact that pesticide use among small-scale, subsistence farmers is currently very limited, resistance is not expected to be an issue initially. But the introduction of pesticides and continuous use over time enhances the probability that resistance will develop, particularly in vegetable culture. The use of pesticides within an IPM framework, as required by this PERSUAP, is a key measure in preventing resistance development. Monitoring is required, however, to confirm that the pesticides being recommended will perform as expected in Niger. Evaluation of pesticide efficacy (and of pest management plans more generally) is a required part of demonstration plot management. Monitoring for and reporting of resistance development is a required element of SUAP compliance reporting.

g) Compatibility of the proposed pesticide use with target and non-target ecosystems.

This factor of analysis examines the potential effect of the pesticide on organisms other than the target pest. Toxicity profiles for each pesticide can be found in Table 7 under Factor E, above. The potential for negative impact on non-target species should be assessed and appropriate steps should be identified to mitigate adverse impacts. Non-target organisms considered in the toxicity profile of each pesticide are fish, honeybees, birds, amphibians, earthworms, mollusks, crustaceans, aquatic invertebrates, phytoplankton, and zooplankton. Toxicological data was gathered from a number of sources and was often given in different units that were then converted into the following descriptive categories: very highly toxic (VHT), highly toxic (HT), moderately toxic (MT), slightly toxic (ST), relatively non-toxic (RNT), practically non-toxic (PNT), and not toxic (NT).

In general, organo-phosphates, organo-chlorines, carbamates, synthetic pyrethroids, and the avermectins (botanical macrocylic lactones) are very toxic to the range of non-targets tested. These pesticides are no longer covered by patents, thus many companies can produce them cheaply, which is why they are popular with farmers. They also are not selective and kill beneficial arthropods, such as predators and parasitoids. Sulfur has been used for centuries as a pesticide and is an essential element for human health. However, sulfur is particularly toxic to aquatic invertebrates.

The newer pesticides are safer to non-targets particularly the biologically based ones. **Azadirachtin or neem is only toxic to crustaceans and aquatic invertebrates**. Flubendiamide, horticultural oil, methoxy-fenozide, pymetrozine, spinosad, spirotetramat, and tebufenozide are all new insecticides/acaricides and are considered to be selective pesticides as they spare many non-target organisms including beneficial

arthropods. Biologically based insecticides such as Bacillus thuringiensis (Bt) and nuclear polyhedrosis virus (NPV) are the least toxic materials.

Fungicides tend to be less toxic than insecticides as a rule. However, toxic fungicides to non-targets are azoxystrobin, cyazofamid, kresoxim-methyl. The popular mancozeb is only highly toxic to aquatic invertebrates. The two bactericides Bacillus subtilis and Pseudomonas fluorescens are essentially harmless to non-targets including humans and livestock. These materials are effective materials to counteract bacterial diseases and have consistently outperformed copper-based bactericides, which are more hazardous to the environment.

Regarding threats to bees, honeybees are important pollinators of a number of crops, and as such play a key role in agricultural productivity. Bees cannot only be poisoned on contact with contaminated crops, but also can carry contaminated pollen and nectar to the hive, potentially killing off the whole colony. Risk is reduced by spraying crops pollinated by bees in the early evening when bees are in their hives and warning beekeepers of spray events so that they may protect/relocate hives.

However, this does <u>not</u> address the suspected role of neonicotinoid insecticides (acetamiprid, imidacloprid, thiamethoxam, etc.) as contributing causal agents of honeybee colony collapse disorder (CCD) in Europe and N. America. Although acute toxicity of neonicotinoids to bees is not necessarily high, neonicotinoids are systemic (taken up by the plant) and appear in nectar and pollen, and it is via this route that a chronic toxicity mechanism may operate.

However, the small-scale and asynchronous uses of neonicotinoids envisioned in Niger are judged to present markedly lower risks to bee colonies than the large-scale, synchronous applications in the US and Europe, where hundreds or thousands of hectares may be sprayed at one time. And because of their low toxicity to humans, broad-spectrum uses, and low toxicity to non-insect targets, they have many other desirable attributes. They are thus approved for both seed treatment and soil use under this PERSUAP. This PERSUAP will be amended to restrict neonicotinoid use if asynchronous small-scale applications are shown to present significant risk of CCD and/or if their USEPA registration status changes.

Neonicotinoid use must be monitored for honeybee impacts; spraying must take place in the early evening when bees are in their hives, and notice given to local beekeepers so that hives may be moved/protected. They may not be used on honey-bee pollinated crops when these crops are flowering.

All of the seed treatment pesticides, including the neonicotinoids, are safer in the environment when covered by soil. Therefore, proper planting techniques must be emphasized and monitored.

Neonicotinoid insecticides are approved only for application and use by phytosanitary brigade members.

Commodity protection

As an indoor fumigant, aluminum phosphide presents risks to fumigators and those working or living nearby, but there is not a "target ecosystem" of particular concern.

Indoor use, non-persistence and non-mobility in soil, negligible potential to contaminate surface waters, and a short half-life in air of ~5 hrs (daylight) mean that aluminum phosphide has essentially no interaction with or impact on non-target ecosystems. More information can be found in the Fumigation PEA: http://www.usaidgems.org/fumigationpea.htm.

Since contact pesticide are only for use in and around the warehouse environment, the chances of contamination of the the surrounding environment are low. Additionally, the use of bait boxes for containing rodenticides is necessary.

h) Conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils.

This factor examines issues such as the potential for contamination of soils, biodiversity and especially surface and groundwater sources. Information regarding specific conditions in which all pesticides should be used can be found in Annex 1. Additionally, instructions on the conditions under which a pesticide should be applied, as found on the pesticide label, must be adhered to.

Rain-fed, staple, or cash crop improved production; and Vegetable and fodder production IPM and pesticide safer use training

Niger has a very hot and dry climate and sandy lateritic soils. The low humidity means that many of the pesticide droplets will dry up especially if spraying is done during the day rather than late afternoon, which is recommended. Due to the low humidity, fine droplets of water-based pesticides will evaporate before impacting the pest. In this case oil based formulations are preferred.

Sandy soils, on the other hand, mean there is a high potential for pesticides to enter groundwater. Vegetable farmers seek out areas with high water tables, so that irrigation is facilitated. In many places the water table is only a few meters from the surface, as indicated by the use of treadle pumps. The hot climate, however, will ensure that pesticides will breakdown in the soil quickly so that if percolation rates are not high, much of the pesticide will be decomposed after a few days. Due to the low rainfall there are relatively few surfacewater bodies that pesticides could pollute.

The crops in small-scale, subsistence farms in Niger are likely under nutrient and water stress much of the time due to the poor soils and the low amount of nutrients that farmers can apply to their fields and the lack of steady rainfall respectively. As a result, losses from pests will be higher than if the crops were well fertilized and watered. Farmers should devote more of their scarce resources to securing high quality seed and organic forms of fertilizer rather than purchasing pesticides to reduce the overall impact that pests have on their crops.

Part of the reason for the poor soils in the program areas is wind erosion from incessant high winds that have swept away the lightest soil particles, including organic matter, leaving only the heavier sand. Many pesticides cling to organic matter and clay particles and these would be carried with the winds which have been reported to go as far as the Amazon basin. The impact of this phenomenon, though, is not significant.

Livestock health and sanitation

As with any pesticide, use that is inconsistent with the label specifications is not allowed. In general, when applying pesticides to livestock, applicators will not allow people without required PPE or animals not receiving treatment in the treated areas until sprays have dried. Other non-target species should be removed form the spraying area when possible. Precuations are also to be taken to avoid drift onto pastures, crops, poultry ranges, or water supplies (e.g., treatment will be avoided on windy or rainy days).

Commodity protection

Aluminum phosphide will be used solely for indoor fumigation of warehoused food commodities. USAID requirements are presented in the Fumigation PEA: http://www.usaidgems.org/fumigationpea.htm. Indoor use, non-persistence and non-mobility in soil, and negligible potential to contaminate surface waters (see "factor e," analysis, above) mean that geography, hydrology and soils have negligible bearing on safety, efficacy or appropriateness.

Climate is relevant only in that extremely dry air can retard formation of phosphine gas from phosphine tablets, requiring appropriate adjustments to fumigation protocols. This is anticipated to be an issue in Niger, where typical indoor temperatures can be very hot and dry.

The contact pesticides, Chloropyrifos-ethyl and Pirimiphos-methyl will be used solely for spraying the interior and immediate perimeter of empty warehouses; and, the rodenticide Brodificoum will only be used within said warehouses in protective containers.

The warehouses are located in the center of the Sahel, in the towns of Maradi and Zinder in southern Niger, near the border of Nigeria. The soils are mixed sandy and clay with little loam and a hard calcium sub-layer called caliche. There are no major bodies of water nearby and groundwater is deep (beyond 30 meters). Very little wildlife, other than rodents and some ubiquitous and not endangered lizards, sparrows, and starlings enters warehouses. Risks for contamination of soil and water resources (surface and ground water) are low, as are risks to biodiversity.

Warehouses have concrete floors and walls and zinc (tin) roofs, and have ventilated window slats high on the sides of the building. Window slats and the wall-roof junction (open in some warehouses) and are sealed with screen to prevent insects, rodents, and birds from entering. The doors close tightly to the ground, which should keep most rodents out.

- CRS has one warehouse in Maradi, which is located within the CRS walled office compound, 30m from the offices, and is located in a mixed commercial and residencial part of the city.
- MC has two warehouses, one in Maradi, the other in Zinder; the warehouse in Maradi is the sole structure in a vast, walled compound, abutted by other warehouses and a milk processing plant; the warehouse in Zinder has two smaller warehouses within a small, walled compound, surrounded by compounds containing a total of ten other warehouses of various uses.
- SCI has one warehouse in Maradi that shares a spacious, walled compound with two WFP warehouses, and is located in a mixed commercial and residencial part of the city.

i) Availability of other pesticides or non-chemical control methods.

Niger has limited options for chemical pest control and many new, less toxic alternatives have not yet become available on the market. A RECA 2013 survey of pesticides available from a number of sources, including in all of the program areas was used to determine that many approved products are available, and the programs should conduct their own surveys to assess the local market available to the communities they work in.

Rain-fed, staple, or cash crop improved production; and Vegetable and fodder production, IPM and pesticide safer use training

While the list of available pesticides will certainly fluctuate unpredictably due to the proximity of Nigeria, USAID partners will, whenever possible, work with agrochemical suppliers to increase awareness of the hazards of highly toxic pesticides currently in use (such as USEPA Restricted Use Pesticides (RUPs) and advocate for increased supplies of safer alternatives, such as botanicals and biopesticides. As vegetable growing will be expanding, there will be a need to rotate pesticides to keep pesticide resistance from developing, so relying on the core group of effective but higher toxicity pesticides is not a recommendable course.

IPM operates under the philosophy that it is more effective and safer to challenge pests with diverse control measures rather than with just a few kinds of pesticides. Currently farmers utilize a few cultural control practices, such as crop rotation and intercropping to supplement the preference for pesticides. Host plant resistance should play a larger role as the basis for pest management, and the government needs to encourage more local testing of germplasm and to expand certified seeds and make them available locally. ICRISAT and INRAN are working on developing pest resistance in the staple crops. Private seed companies have developed resistant strains to combat many serious pest problems and these resistant planting materials should be actively tested for efficacy and then promoted based upon results.

Regional biological control laboratories produce colonies of beneficial organisms such as arthropods or entomopathogens. There are a number of these that can be mass produced and given to farmer organizations to continue to produce them locally using simple technologies such as culturing them on cereal grains in plastic bags. Simple rearing chambers can be made to mass-produce egg or larval parasitoids in farm communities. ICRISAT and INRAN are currently developing this idea to control millet head miner by mass rearing a larval parasitoid. The IPM CRSP in Senegal is expanding this idea, as are other international organizations in plant protection.

Livestock health and sanitation

As noted prior in this PERSUAP, during an interview with the Department of Livestock and Animal Husbandry of Matameye, it was mentioned that certain highly toxic products were still being recommended for use by the veterinary services of the Department. For instance, lindane, a highly toxic pesticide and known carcinogen, are still available, yet not allowed by this PERSUAP due this toxicity level.

Commodity protection

The fumigation PEA assesses the effectiveness and availability of non-chemical control methods (http://www.usaidgems.org/fumigationpea.htm). As noted, the Safer Use Action Plan requires good housekeeping IPM measures, such as daily sanitation of the warehouse and weekly clearing of warehouse

surroundings of weeds, daily inspections for pests, and strictly adhering to the first in first out (FIFO) rule to minimize the storage time of the commodities in the warehouse.

The complementary contact pesticides, chloropyrifos-ethyl and pirimiphos-methyl will be used to kill insects escaping fumigation and prevent re-infestation of the commodity. As documented by the Fumigation PEA, such complementary use of contact pesticide in and around warehouses is usually an integral part of the fumigation process.

j) Partner country's ability to regulate or control the distribution, storage, use, and disposal of the requested pesticide.

Host country registration status of all considered pesticides is documented under Factor A, above. As a Member State of the Permanent Inter-State Committee for Drought Control in the Sahel (CILSS), Niger has ratified the common rules *LEX-FAOC019673* for the approval of sale and use in each respective country of pesticides intended for use in fumigation, cultivation, and livestock breeding, including many "biopesticides." See Section 2.3 for a summary description on Niger's pesticide regulatory framework.

In addition to the regional framework, all CILSS member countries have interdisciplinary national pesticide management committees which function as national platforms for the exchange of information on pesticides. It is the job of the DGPV extension service to ensure that international and national policies reach the local level of the agricultural sector. Due to the sometimes scanty coverage of local agents and a general lack of funds to have more people on the field, local enforcement of national pesticide regulations is generally poorly implemented.

A particular lack of enforcement exists in the program areas which are in the proximity of the border with Nigeria. Most pesticides come across the border either by farmers traveling to, or vendors travelling from Nigerian border towns that have numerous pesticide outlets that import pesticides from all over the world. Nigeria is not a CILSS member state and the level of enforcement of its own pesticide regulations is unknown. What is known is that there is little import control from Nigeria and thus little enforcement of registered product regulations or enforcement and monitoring of distribution, storage, use, and disposal of accessible pesticides.

Due to the lack of a cohesive solid waste program in Niger, empty pesticide containers are usually inappropriately disposed. Farmers claimed to dispose of empty pesticide containers by burning them in a pit away from residential areas, and covering the pit with soil. Agrimex transports all expired pesticide back to Niamey and burned by staff from the headquarters office, under the supervision of the Office of Pesticide Registration.

It should be noted that this PERSUAP is aware of the issues associated with the above mentioned disposal methods. Open-burning of pesticide containers in pits should be discouraged as pesticide containers may emit harmful smoke and vapor when burned at low temperatures. Rather, programs are to promote proper practices, such as incineration of containers when a well-operating incinerator is available or the triple rince, puncure, crush, and bury (i.e., in a locally established landfill or waste dump) method, instead as indicated in

the SUAP. Title II program implementing partners should vet the waste dump to ensure that container disposal will not pose threats to nearby residents, water table or surface water, drinking water sources, livestock or other animals. An awareness campaign especially targeting children, women and non-farmers will be beneficial to discourage the re-use of pesticide containers. It will also be beneficial to create a communal container collection program for farmers and agro-dealers alike to dispose of their waste in a safer manner.

In order to avoid having residual pesticides, the Agrimex pesticide store owners stated that they request only exact amounts of pesticides be brought in from the Niamey office.

Obsolete pesticides need to be destroyed and must be transported to Senegal where they can be incinerated. The Ministry of Environment reports a major backup of containers and obsoletes for disposal. It is unclear how effective enforcement of disposal requirements is in the private sector. Use of expired products, according to label directions is often the most feasible manner to dispose of expired products given the lack of disposal systems for expired products and the generally limited access of farmers to inputs due to financial constraints.

It is concluded that Niger has limited ability to regulate pesticides and, as such, the programs must take steps to promote sound pesticide use (including improved handling, mixing, application with appropriate PPE, and storage and disposal practices with an emphasis on IPM among partner agro-supply stores, contracted private service providers, government extension services, GoN-trained and epuipped phytosanitary brigade members, and beneficiary farmers (see SUAP Section 6 – Safer Management of Pesticide Wastes).

Commodity protection

Aluminum phosphide fumigation does not specifically require a license in Niger. However, Title II programs must ensure that Fumigation Service Providers (FSPs) have the capacity and necessary equipment to comply with the fumigation and contact insecticide use conditions contained in the Fumigation SUAP (Section 7) and the Fumigation Management Plan (FMP) found in Annex 2. More information can be found in the Fumigation PEA: http://www.usaidgems.org/fumigationpea.htm.

k) Provision for training pesticide users and applicators.

USAID recognizes that safety training is an essential component in programs involving the use of pesticides. The need for thorough training is acute in Niger, where the level of education of applicators may typically be extremely low. Resources within this PERSUAP, such as the IPM planning tables and reference material (Annex 1) should be utilized for training development in addition to other resources, such as the FAO and the pesticide industry standard "Crop Life" body of work.

The widespread use of posters and visual and practical training aides placed in areas where farmers gather and in training sessions for farmers should be promoted. The programs will also translate the labels of commonly-used pesticides into Hausa, and create datasheets for these pesticides that are relevant to the pest problems and application recommendations specific to the target program areas in order to distribute them to beneficiary farmers. The program will also work in conjunction with DGPV in order to develop leaflets on approved brands of pesticides and their corresponding crops and pests, in order to make this information, which is often available online, more readily available to farmers.

Commodity protection

Niger FFP partners must become familiar with the USAID Fumigation PEA:

http://www.usaidgems.org/fumigationpea.htm. USAID recognizes that safety training is an essential component in programs involving fumigation of stored commodities. The need for thorough training is particularly acute in Niger, where the level of education of applicators may typically be lower than in the US. In addition, the USAID requirements for Fumigation Safer Use Action Plans require that FSPs have access to all of the following equipment, which will often need to be procured outside of Niger by the programs because the equipment is not currently consistently in use by FSPs:

- Cannister or catridge style respirators intended for protection against inhalation of phosphine gas.
- Fumigation gas monitoring device (i.e. Draeger tube or electronic phosphine gas measuring device).
- Gas-impermeable tarps/sheets (i.e. vinyl-coated nylon or similar material).
- Locks and warning placards placed at key entry-ways into fumigation that is underway.

Given that aluminum phosphide is a RUP, and is required to be applied by a certified applicator, the programs have determined that the fumigation service providers available have limited capacity for safe and effective fumigation and that there is a need to bolster the FSP capacity were it is found to be deficient. **Title II** programs using FSPs without access to required equipment, must invest in necessary fumigation equipment and train FSP staff in its proper use. This will be the only way that the program can ensure fumigations are safe and effective. See the FMP, Annex 2, for more of the required specification of respirators, fumigation monitoring devices, tarps, etc. to be used during all fumigations.

I) Provision made for monitoring the use and effectiveness of each pesticide.

Through use of the PERSUAP Environmental Mitigation and Monitoring Plan (EMMP), see Section 4, pesticide safer use and effectiveness will be monitored as part of field visits by program agronomists, local implementing partners, and field staff who spend significant time in the field and on farms, monitoring cultural practices, crop health, and pest control, and providing technical assistance to farmers when problems arise. Implementation of the EMMP will be managed by the Environment Specialist and the Chief of Party of each of the three programs. It is also recommend that partner stakeholders from the Pesticide Committee of the Ministry of Agricultural Development, Department of Agriculture, and Plant Protection Division be made aware of the pesticide use pre-cautions being promoted by the projects as part of this EMMP.

Actions taken to ensure compliance with the conditions of this PERSUAP are required to be reported upon annually in the Environmental Status Report (ESR) to USAID. As part of this reporting, implementing partners directly supporting farm-level pesticide use or extension will be required to report to USAID and the Ministry of Environment/DGPV on instances observed of pesticide resistance. USAID Monitoring and Evaluation (M&E) field visits will examine pesticide compliance, as well.

Commodity protection

The SUAP, which follows in Section 4, below, requires a Fumigation Management Plan (FMP), as per the USAID Fumigation PEA requirements (http://www.usaidgems.org/fumigationpea.htm), to serve as a detailed

log of fumigation practices implemented for each warehouse treatment. The FMP requires efficacy monitoring of phosphine gas concentrations to better assure that required concentrations are attained for the required period. This is critical to the efficacy of the fumigation and to preventing emergence of resistance. Monitoring of commodities for infestation is a routine element of program management; quick reinfestations are the primary indicator that fumigation is ineffective.

SECTION 4: SAFER USE ACTION PLAN

This Safer Use Action Plan <u>is the definitive statement of program pesticide compliance requirements</u> and is also synthesized from the PER analysis. It should be made clear that all parts of the PERSUAP apply separately to each Niger FFP program. Each program is expected to apply the SUAP to their relevant activities.

Mitigation measures and restrictions, attendant to use/support of the pesticides approved in this PERSUAP, can be <u>summarized</u> as follows in the PERSUAP's **Environmental Mitigation and Monitoring Plan (EMMP)**, **Table 10**.

It is expected that programs will modify this EMMP as needed and <u>assign appropriate responsible parties</u>, <u>and determine appropriate data collection instruments and methods</u>, within their program to be responsible for the monitoring of the mitigation measures and indicators provided.

The below documented mitigation measures seek to reduce, to the greatest extent possible, negative impacts associated with pesticide use, such as acute/chronic exposure, poisoning, crop loss due to pest/disease damage, unknown human health impacts from use of unregistered or counterfeit products, risk of exposure, including exposure of children in homes, reuse of pesticide containers leading to acute/chronic toxicity, over-spraying, contamination of water sources or aquatic organism toxicity, impacts from spray drift, and effects, such as cancer or organ diseases from long-term exposure

All FFP programs will be responsible for ensuring all of the mitigation measures and required monitoring occurs for each related activity.

Table 10: Environmental Mitigation and Monitoring Plan

Monitoring	Monitoring
Frequency	Indicators
Bi-annually	Only
	approved
	pesticides and
	GoN-
	approved
	pesticide
	vendors are
	being
	supported or
-	Frequency

- Pesticide support must be governed by locally adapted, crop- and pest-specific IPM plans and use restrictions for each of the four categories of pesticide use outlined in Section 3.1. Use restrictions dedicated to each use category are found in the factors of analysis (Section 3.3 a-I)). The PERSUAP provides IPM plans in Annex 1 for further development and use by programs.
- The purchase of pesticides by any program-supported purpose must be from a GoN-certified pesticide supplier.
- Pesticide use supported by the program must ensure that applicators exercise care around sensitive non-target ecosystems (surface waters) and other areas (bee-keeping houses, etc.)
- For any pesticide use, the programs must ensure that pesticide wastes are disposed of following best disposal practices (see Section 6 on Safer Management of Pesticide Wastes).
- To the greatest degree practicable, programs must require use and maintenance of appropriate Personal Protective Equipment (PPE), as well as safe pesticide purchase, handling, storage, and disposal practices by all parties applying pesticides with funding from program activities.
- Programs must be systematic in their pesticide-related recordkeeping and monitoring. The programs subject to this PERSUAP must provide an annual update on SUAP compliance.

used by programfunded activities (Yes/No)

Integrated
Pest
Management
plans are used
as the basis
for all
programs'
pesticide use
(Yes/No)

Are nontarget areas, vulnerable to pesticides, protected from program supported pesticide use activities (Y/N)

Is appropriate
PPE being
used by
pesticide
applicators
funded by
program
activities
(Yes/No)

Are all used pesticide containers being disposed of safely (i.e.

		triple rinsed,
		punctured
		and buried,
		not burned in
		open pits)
		(Yes/No)
Rain-fed, staple, and cash crop improved production; and Vegetable and f	odder productio	on. IPM and
pesticide safer use training	ouder productive	21.) 11 111 unu
Any application of pesticides by a program will require a GoN-	Bi-annually	Only GoN-
trained and equipped phytosanitary brigade member to apply the		trained and
approved pesticides; program support of farmer's pesticide		equipped
application is also contingent upon the farmer contracting a GoN-		phytosanitary
trained and equipped phytosanitary brigade member to apply		brigade
approved pesticides.		members are
 When involved in pesticide or pesticide-related training, 		applying
programs must focus the curriculum on IPM. It is important that		pesticides on
farmers are sensitized to a number of issues pertaining to		crops with
preconceived notions of the benefits of pesticides. In addition to		support of
the IPM training topics that could be addressed, it is necessary		program
that the programs train farmers on safer pesticide use (Section 5).		funds
For any program demonstration or testing of pest management		(Yes/No)
practices, pesticides should only be used as part of an IPM		
program that includes cultural and other non-chemical controls in		Are all
order for beneficiaries and community members to see the value		demonstratio
of an IPM approach to pest control.		n sites of the
		program using
		non-chemical
		control
		methods for
		pest
		management
		(Yes/No)
		Niconal
		Number of
		beneficiaries
		trained in IPM
		and safer use
		of pesticides
		for crops
<u>Livestock health and sanitation</u>		

- The programs should work closely with the Ministry of Livestock and Animal Husbandry to ensure that the conditions for preventing pest outbreaks are maintained during breeding operations.
- The programs should include: a) practices to help prevent pest problems, b) training on how to diagnose pest problems when they arise, and c) provide information on how to access Ministry of Livestock and Animal Husbandry extension services when needed.
- For any livestock pesticide use supported by programs, only a trained and certified Ministry of Livestock and Animal Husbandry agents, using the required application and safety materials, may apply the permitted pesticides for their specified use (see in Factor E of the PER factor analysis and Annex 1).

Are only
Ministry of
Livestock and
Animal
Husbandry
agents
applying
pesticides on
livestock as
part of
activities
funded by
program
(Yes/No)

Number of beneficiaries (cumulative) trained in non-chemical pest prevention for livestock

(See

Fumigation SUAP and

Commodity protection

- Fumigation of stored Title II commodities must utilize the tools, and comply with the conditions in the USAID Programmatic Environmental Assessment (PEA) for Phosphine Fumigation of Stored Agricultural Commodities for program fumigation planning, mitigation, and monitoring as outlined in the Fumigation Safer Use action Plan (Section 7), the Fumigation Management Plan (FMP) (Annex 2), and the annexes and tools in the USAID Fumigation PEA:
 http://www.usaidgems.org/fumigationPEA.htm.
- Local Niger Fumigation Service Providers (FSP) will be contracted for fumigation, contact insecticide sprays, and application of rodenticide when needed to protect warehoused commodities.
 The Terms of Reference (TOR) for the contracted party needs to clearly require their compliance with the FMP.
- If the FSP cannot provide the equipment/material/products
 required for any needed fumigation, insecticidal sprays or
 application of rodenticide recommended by this PERSUAP, it is
 the responsibility of each Title II program to work with the FSP or
 organization providing the service to ensure that access to

Each fumigation event

Fumigation
Management
Plan
templates
provided in
this PERSUAP)

- required equipment, or provide it directly, and train FSPs in the proper use of all fumigation and applicator personal protective equipment or other equipment required by this PERSUAP (see Annex 2, Fumigation Management Plan).
- The use of fumigants is contingent on the programs ensuring all relevant conditions/mitigation measures for the use of phosphine gas are implemented following the manufacturer's label instructions

(http://www.degeschamerica.com/docs/USA/Fumex%20manual.pdf).

SECTION 5: TOPICS TO BE PART OF PESTICIDE SAFETY TRAINING

USAID-Niger programs are expected to develop training curricula and materials on safer pesticide use guidance in the following content areas outlined below. At the time of PERSUAP development, there are no plans for the Niger FFP programs to develop materials together; hence, each program will be responsible for complying with instructions outlined herein. If programs decide to share matrials and material development, they may do so, but must ensure all components outlined in this PERSUAP are covered for each respective program and the program's activites.

Pest knowledge, monitoring, and action thresholds

Using the agroecological reference material on pests and the crops they affect in Annex 1, as well as additional sources (particularly research and training materials developed by INRAN or ICRISAT), train farmers how to identify pests and beneficial insects (to protect them, as part of the IPM strategy), appropriate pest control methods and action thresholds for deciding on pest control action. In consultation with partner research institutions, extension staff, and farmer groups, the programs should develop farmer leaflets and posters in Hausa for key pests of each crop being considered to be included in the training program, as well as integrated pest management methods for these pests. Due to very low literacy rates among rural Nigeriens, posters and leaflets will need to contain very little text and convey most information via visual means (diagrams, photos) to be effective. Trainees should be instructed how to teach other community members how to use these materials.

Chemical knowledge

Registration, correct use, application procedures, and label specifications. This training includes an indepth review of label information (resources in Hausa and/or with photos/drawings should be provided wherever possible), as well as a discussion of dosage, application rates, equipment calibration and maintenance, application intervals, re-entry, and pre-harvest intervals and demonstrations of proper equipment use. To address issues of literacy during training on safe use of pesticides, materials should focus on pictorial representations of the key pests for each crop being considered, as well as proper vs. improper pesticide selection, mixing, application, storage, etc. Farmers will be encouraged to buy products only from reputable dealers selling registered products. The effectiveness of farmer training will be complemented by program partnership with local DGPV agents, GoN-trained and epuipped

phytosanitary brigade members, and agro-supply dealers to work towards improving the selection of pesticides available to farmers and ensuring that only CSP and PERSUAP approved pesticides are used.

Pesticide resistance

Farmers need to know how to prevent pesticide resistance from developing, particularly on vegetables that are grown 3-4 times a year. Once resistance develops, all pesticides in that particular class of pesticides, for example synthetic pyrethroids, will no longer be toxic to pests. Farmers need to be taught that by coordinating their pesticide usage at the beginning of the season by rotating pesticide classes each season in an organized way they can prevent or delay development of resistance. Selective pesticides should also be promoted in place of the more toxic, general pesticides that are currently the most available.

Storage

The programs will promote proper storage of chemicals in a pesticide storage shed at an appropriate distance from other structures on the property (i.e., 30 meters from water sources). A separate, clearly marked with a "Danger" sign/drawing on the door alerting other members of the community and especially children, on the danger of the products that are locked within. Steel storage containers or other, leak-proof, simple structures large enough to store pesticides in original containers, upright with a lock can be promoted where a community shared storage facility is not an option. Farmers and family members will be encouraged to keep pesticides away from food for human or animal consumption and sources of drinking water, to store powders above liquids, and to always store pesticides in their original containers.

Transport

Safe transport of pesticides should be discussed and may include topics, such as not using public transportation, keeping chemicals in a contained environment, and secured using tie-down rings or steel racks for example, not buying or transporting leaking or damaged chemicals, and information on how to avoid punctures and torn bags.

Worker protection

Training curricula should cover the types of personal protective equipment (PPE) needed for different fungicides and insecticides, and when they should be worn and why, and how they should be cared for by the applicator. The basic PPE recommended for all pesticide applications involving pesticides in toxicity Class III and IV includes long-sleeved shirts, long pants, closed shoes (preferably boots), socks, and a non-cotton hat. For pesticides in toxicity Class I and II chemical-resistant gloves, coveralls, goggles, and masks or air-purifying respirators need to be added. These are general guidelines that may vary in the case of specific products. In all cases the PPE used for any given product should be consistent with the label's instructions. Applicators should be encouraged to wash PPE separately from everyday clothing and to keep their PPE well-maintained (i.e., free of holes especially the gloves, no torn shoes or boots, and cartridges for air purifying respirators changed regularly).

Safety practices

Farmer safety training should address proper mixing techniques, the importance of using clean water free of particulate matter for mixing, equipment maintenance, and practices to avoid water

contamination. The types of containers used in chemical preparation, their proper use, cleaning, storage, and disposal will be addressed. How to calibrate and safely maintain nozzles for spraying equipment will be discussed, including ideal calibration for economical effective coverage and to avoid practices, such as blowing into the nozzle to free it of debris. Applicators should be encouraged to spray when the wind is at their back to avoid wind blowing the chemicals on them. Applicators should also be taught not to eat, drink or smoke while applying pesticides and to apply warning signs after advising neighbors that they have sprayed. Demonstrations of proper equipment use and maintenance will be a key part of this training topic. Sprayer calibration clinics should be held each season to show farmers how to apply the correct spray volume and to measure the optimal amount of pesticide to place in each sprayer load. If any solution is left after spraying, it should be disposed of away from the crop and areas of human activity. Spraying equipment should be washed at the site of spraying and the rinseate disposed of far away from a water source in a fallow area with grass so a puddle that livestock may drink is not formed. Demo plots, should also have a broom, sand and plastic bags on hand in order to clean up accidental pesticide spills.

Safe pesticide purchasing and application

Farmers should be taught the human and environmental health risks associated with the use of unauthorized pesticides and improper pesticide use. Unofficial pesticides may be tampered with in a number of ways and may pose additional risk to anyone handling them, even with otherwise proper PPE. They may be especially harmful to crops and ecosystems because their toxicities and concentrations may be adulterated. They should also be taught how to identify fake products through lessons on correct product labeling and packaging. Farmers should also be taught the relative advantages to purchasing legal products from legal sources and should be informed of the existing governmental agricultrural systems in place to reduce the risk of pesticides to farmers. The pesticides approved by this PERSUAP that are CSP-approved at the time of training should be discussed in terms of availability and where and how farmers can obtain products and how they can contract PERSUAP approved applicators.

Benefits of contracting GoN-trained and epuipped phytosanitary brigade members

Expanding on the exposure to safe purchasing and application options available, the benefits to farmers in terms of reduced risk to humans and the environment, effectiveness against pests, and cost efficiency of hiring a GoN-trained and epuipped phytosanitary brigade member to apply pesticides should be stressed. While the main reason farmers prefer to buy unofficial products is their cheaper price, product accuracy and proper application should make spraying of official products in the correct way should be more effective for the price, let alone the benefit to the farmer in terms of health and environmental protection. If the programs decide to start a program of cost support for pesticides available for farmer purchase, farmers should be informed of how to access this service and how it works to save them the expense of appropriate materials and application.

First aid and medical facilities

First aid materials should be made available (soap, clean water for eye wash and a towel) in case of spills. Trainers, staff in local health clinics, and agrochemical input supply store staff should have material safety data sheets (MSDS) in addition to label information for all approved or widely used chemicals for reference. Farmers will be taught to identify the primary symptoms of chemical exposure and what do to

in case of an emergency. Staff should also raise awareness on the dangers of pesticides to pregnant women and children.

Waste management

This topic will include how to clean up and safely dispose of any unused chemicals. For liquids, empty containers should be rinsed 3 times, and emptied into the spray tank as part of the application mixture. When the product is used completely, chemical containers should be triple rinsed and punctured before being buried at least 30cm underground. Containers should **never** be reused. An awareness campaign especially targeting children, women, and non-farmers will be beneficial to discourage the re-use of pesticide containers. It will also be beneficial to create a communal container collection program for farmers and agro dealers alike to dispose of their waste in a safer manner (see Section 6for further information on safe waste management).

Storage

Proper storage of chemicals should be taught to farmers in relation to other structures on the property. The need for a separate, clearly marked, and locked facility will be emphasized for exclusive storage of farm chemicals. Pesticides should be kept away from food for human or animal consumption or sources of drinking water. Pesticides should **always** be stored in their original containers.

Protection of water sources

Training will emphasize the importance of protecting potable water sources and avoiding contamination of ground and surface waters. For all pesticides with aquatic toxicities or potential to contaminate groundwater the USEPA buffer of 25ft/8m, as commonly listed on pesticides labels as part of use restrictions, should be respected. Participants should be trained to identify their drinking water sources and to keep all agro-chemicals away from these sources. Mitigation measures to avoid contamination of water sources should be promoted.

Environmental safety, monitoring and reporting to USAID

Reporting on the EMMP will be part of the Environmental Status Report (ESR) submitted annually to Food for Peace programs. Training may be be required on these and other USAID documents and analyses.

Additional Training References: The WHO and FAO have signed a Memorandum of Understanding (MOU) for a joint programme to promote sound management of pesticides. The "International Code of Conduct on the Distribution and Use of Pesticides," embodies many of the key recommendations and support activities of this joint programme available online at the following link,

http://www.fao.org/WAICENT/FAOINFO/AGRICULT/AGP/AGPP/Pesticid/Code/Download/code.pdf.

Additional WHO references on pesticide management and public health can be found online, http://www.who.int/whopes/recommendations/who fao meetings/en/index.html.

SECTION 6: SAFER MANAGEMENT OF PESTICIDE WASTES

Types of common pesticide waste and best practices:

i. Empty containers

- Rinsing will occur before pesticide application so that rinse water can be used to dilute the product. Up to 5% of the water used for dilution can be rinse water.
- Empty drums, bottles and cans will be triple rinsed.
- Holes will be punched in the container to prevent reuse.
- The container can then be buried in a sanitary landfill, recycled or burned if local regulations and product label allows.

ii. Excess mixture

- Excess mixture should be avoided by careful calculations and measurements.
- Excess mixture should be applied to a labeled site.
- Once mixed, most products cannot be safely stored.

iii. Rinse water from containers and application equipment

- Rinse water has great potential to contaminate water sources both above and below ground.
- Do not discharge to ground, drains, or septic systems. Instead discharge should be placed into a hole away from water sources, including underground water sources, and buried.
- Rinse water should be minimized and applied to a labeled site.
- Reuse rinse water to dilute the next batch of the same product.
- Up to 5% of water used for mixing can be rinse water.

iv. Spilled material

- Spilled material will be immediately cleaned through the use of an absorbent material. For example, soil, sawdust, etc.
- If done shortly after the spill, the absorbent material can then be placed in a suitable container and applied to an approved site (such as a crop field) in a manner consistent with the product label.

v. Obsolete and Unused Pesticides

- Pesticides become obsolete for the following reasons:
 - ✓ Banned products.
 - ✓ Substandard storage and management.
 - ✓ Prolonged storage as a result of overstocking. Product expiration.
- Pesticides should be taken to the nearest hazardous waste management center, if available.
- Certain pesticides can be destroyed in normal cement incinerators while others require specific high temperature toxic waste incinerators.
- If there is no safe way to destroy the product, field application according to the product label is likely to be the safest alternative.

vi. Neutralization of Metal and Glass Containers

- Metals and glass containers (barrels, cans, drum, jars) contaminated with organophophorous, organochlorine compounds and derivatives of denitrophenol and other pesticides can often be neutralized with alkaline solutions (soda, wood ash, lime).
- The containers are filled with 5% solution of caustic or washing soda and left standing for 6-16 hours and are then repeatedly washed with water.
- Containers emptied of carbamate pesticides (thiram, carbayl), for examples, are neutralized
 using a 1% solution of potassium permanganate acidified with hydrochloric acid (5ml/liter)
 or a paste of lime chloride.
- Poper baseline protective equipment (long pants and shirts, gloves, goggles, shoes plus socks and for extended exposure to lime dusts a dust filtering face mask) will be necessary when handling neutralizing solutions.

SECTION 7: FUMIGATION SAFER USE ACTION PLAN

In light of analysis above, and the USAID Fumigation PEA, warehouse food commodity phosphine fumigation for CRS PASAM-TAI, MC Sawki, and SCI LAHIA food commodities and use of the complementary contact pesticides Chlorophyriphos-ethyl, and Pirimiphos-methyl and the rodenticide brodifacoum are recommended for approval subject to full compliance with and implementation of the Fumigation Safer Use Action Plan (SUAP) and Compliance Tracker (Annex 3).

This SUAP imposes the following mitigation measures established by the Fumigation PEA (http://www.usaidgems.org/fumigationpea.htm) and required to be implemented by all programs as part of their commodity protection activities:

- Implementation of good-housekeeping IPM Measures that are essential complements to fumigation per USAID Fumigation PEA Annex T-5.
- Implementation of a Fumigation Management Plan for each fumigation event substantively conforming to the plan provided as Annex 2.
- Complementary Use of Contact Pesticides will (1) be limited to the pesticide(s) authorized by this PERSUAP and substantively conform to contact pesticide best practices as set out in Fumigation PEA Annex T-6, EXCEPT as noted in the SUAP.
- Storage and Transport of Aluminum Phosphide and Contact Pesticides, if under program control, will substantively conform to contact pesticide best practices as set out in Fumigation PEA Annex T-6, EXCEPT for changes specified below and/or subsequently approved by the DCHA BEO.
- Food and feed commodities that have been fumigated with phosphine must be held and aerated for 48 hours prior to distribution.
- Monitoring and Corrective Actions. Program will actively monitor compliance with above-listed conditions and undertake corrective actions as needed.

ANNEX 1: CROP, LIVESTOCK, AND COMMODITY INTEGRATED PEST MANAGEMENT (IPM) PLANS

DISCLAIMER: The information in this section is meant to serve as a reference for each Niger FFP program when developing their training curricula that will lead to an IPM program. This section will serve as a guideline only and only covers select crops.

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HIBISCUS

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What is IPM:

IPM is a philosophy of pest control that seeks to bring about effective, economical, and sustainable protection of a commodity. It is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques, such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials [pesticides] are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. The philosophy encourages multiple pest control tools to be used against each key pest with chemical control as the tool of last resort because it can have very severe effects on the ecological balance of the particular agro-ecosystem. IPM can include possible pest management techniques and tools including:

• Setting up effective quarantine measures to prevent entry of new pests;

- Properly identify pests of each crop and search for literature to understand the bionomics of each;
- Establish relationships between the density of each pest or pest combinations and yield loss;
- Establishing field monitoring protocols and thresholds (based on the pest-pest density interaction) used in decision-making on when to take corrective action;
- Cultural methods that promote pest avoidance and a healthy plant that can better tolerate pests.
 These methods include, but are not limited to, use of resistant varieties, early/late plantings/harvestings, crop rotation, pruning, destruction of crop residues and pest refuge plants near fields, and GAP practices;
- Developing new varieties that possess genetic resistance or tolerance of pests;
- Natural pest control by encouraging and protecting parasitoids, predators, and pest diseases (ie.
 planting predator-attracting plants/flowers on field margins, protecting natural enemies by use
 of selective pesticides, rearing and releasing natural enemies);
- Mechanical weed or insect pest control using manual, hoe and machine practices;
- Physical control by use of traps (eg. sticky traps, pheromone traps) or barriers (to protect stored commodities) or heat/cold;
- Chemical practices such as use of judicious, knowledgeable, and safe application of synthetic and 'natural' (derived from nature; extracted from plants, microbes, and other organisms) pesticides.

The strongest selling points for IPM beyond the health and environmental benefits are:

- IPM is more effective than synthetic pesticides in the long run (sustainable).
- IPM is less damaging to the natural resource base of each agro-ecosystem.
- IPM generally requires less capital (but more knowledge) investment.
- IPM can be used preventatively to eliminate or minimize the need for —responsive controls (eg. applying pesticides after a pest outbreak occurs to an already damaged area).

Using this annex for Creating Crop- and pest- based Pest Management Plans (PMP)

In consultation with research, extension staff and farmer groups the programs need to identify which key pests are of concern for each crop and then develop standard control practices for their management including pesticides to be used for each pest. Also crop monitoring protocols need to be developed for the key pests based on examples given this Annex. For each crop being considered, the programs should develop a single sheet farmer leaflet in the local languages giving the recommended control practices and monitoring methods for selected key pests. There should also be wall posters developed for IPM for each crop including color photos of each pest so farmers can learn to recognize them and use standard naming for them. Photos can be obtained via Google through typing the scientific name and the word 'photo'. Key IPM gaps in understanding or scientific information are:

- Action thresholds need to be developed for the key arthropod pests and taught to farmers.
 - Not all arthropods in the field are pests and that there are beneficial arthropods that should be spared by using selective rather than broad-spectrum pesticides.
- Control recommendations should include preventative as well as corrective control practices. Farmers should be trained in:
 - the benefits of certified seed, how to disinfect seed, and how to apply seed treatments by practical training.
 - o the wide array of cultural practices most of which are preventative.
 - o the benefit of increasing the organic matter in the soil in bolstering crop vigor so the crops can tolerate pest damage.

- Hands-on exercises should be developed on how to make compost from plant materials collected in their villages.
- that some varieties are resistant to pests and which varieties should be recommended for optimal pest control.

Crops and Pests

In total, the agricultural components of the three projects will provide training on how to cultivate four staple crops (millet, sorghum, groundnuts, cowpeas) as well as 18 vegetables, fruits, oil crops, and tubers (okra, tomato, peppers, eggplant, Irish potatoes, sweet potato, onion, garlic, cabbage, lettuce, squash, pumpkin, watermelon, sesame, carrot, Moringa, Apple of the Sahel). In addition there will be training in livestock raising (sheep, goats, guinea hens, and chickens). Food that will be distributed to beneficiaries also has to be stored in warehouses and stored product pests and rodents need to be prevented from damaging this vital resource.

The information in this section is meant to serve as a reference for developing the training curricula that will lead to an IPM program. This tool was created by interviewing experts in Niger and sourcing literature. Likely pests were determined as part of these interviews. This section will serve as a guideline only and taxonomic accuracy will need to be determined as time goes on. Action thresholds are given for many insect pests which will also need to be verified via field trials.

MILLET and SORGHUM

Pearl millet *Pennisetum glaucum* is the only cereal crop adapted to the Sahelian arid region and is a major subsistence food crop in the Niger, particularly for household use by women. Niger is the world's top producer per capita of millet. In many areas, production of millet beyond the immediate family needs provides an important source of cash income for poorer households. Sorghum *Sorghum bicolor* is also a main crop in Niger because it is a food and cash crop; high yielding; easy to weed; and does not require much fertilizer.

Most varieties of both millet and sorghum are drought- and heat-tolerant. Therefore, they are especially important in arid regions, where the grain is one of the staples for poor and rural people and a source of fodder for cattle, sheep, and goats as well as building materials for dwellings and fencing. Millet is more drought tolerant than sorghum and is therefore preferred by farmers, although sorghum can produce higher yields. Both corps are cultivated in rows and intercropped together with legumes such as cowpea and groundnut in the traditional cropping systems that have shown resilience in the face of drought, poor soil, and minimal fertilizer in the form of animal manures. The mean yield is around 400 kg/ha for millet and around 190 kg/ha for sorghum, but there is variation between agro-ecological regions.

Concerning pests, the unstable nature of the Sahelian ecosystem and the large number of potential pest species create a scenario where the current most important issue may change from year to year. Furthermore, there is a dearth of studies on yield loss in order to pinpoint the most important pests.

Insect Pests

It is noted that the sheer number of serious insect pests attacking millet and sorghum in a given year is unparalleled for cereal crops and is one of the key reasons yields are so low as their combined damage is no doubt exacerbated by abiotic stresses (drought, heat, low soil fertility) that are also prevalent.

White grubs

White grubs are the immature forms of scarab beetles. The milk white grubs or larvae grow to about the size of one's thumb feed on roots of mainly grasses. They dwell in the root zone and roll into a C-shape when disturbed. The adults are usually brown, fly at night during the mating season after the first heavy rains, and are attracted to fields where a large amount of manure was applied. For field monitoring: in 5 areas of the

field, dig up 60 cm row x 30 cm wide x 15 cm deep and record white grubs numbers. If total of 10 live white grubs in 5 samples, economic loss can occur.

Wireworms

The larvae of these small click beetles are shiny, elongate, yellowish to brown with smooth, tough skin. They enter sown seeds and consume them, preventing germination. Damage is most likely to occur where millet and sorghum are planted into a field that had dense populations of grassy weeds. Larvae can be found near the damaged or missing seed or plant.

If wireworms are a common problem then set up bait stations before planting. In 5 randomly selected areas of a field, bury a mixture of seed (a handful in each station) 15 cm deep in the soil. Cover the site with a piece of black plastic to help heat up the soil and mark each site with a flag so that the bait stations can be easily found at a later date. After 2 to 3 weeks, or just before planting, dig up the bait and check for the presence and/or damage of wireworms. If a total of 5 or more wireworms are found then follow the chemical control measures as given in the table below.

Shoot fly Atherigona soccata

The adult gray colored fly lays eggs on the leaves of a newly planted crop. This fly is more important on sorghum than millet where the damage is done by the maggots that attack young seedlings. Infestation begins as early as one week after crop emergence and can continue to about 5 weeks longer until the seedlings become too hard (silica deposition in culms) for the maggots to attack. Late season infestation often triggers profusive tillering in millet but may not result in stand loss as in sorghum. Pest numbers build up with the season.

To monitor put traps made of water bottles with fish meal with tops removed and inverted. Monitor them regularly for one location in each village. If numbers are high, the attack is imminent. Also, look for slender white eggs on the leaves that also indicate an imminent attack. Monitor earlier planted fields in 5 locations of 3 meters and determine the percentage of infested plants. If it is over 15%, treat your seed.

Spittlebugs

These insects which resemble planthoppers lay eggs in plant stems and the ensuing nymphs remove plant sap with their needle-like mouthparts. Nymphs produce bubbles which resemble spit and are used as protection against predatory insects. Even though spittlebugs can cause the death of seedlings and wilting of mature plants, they are not likely to become sufficiently numerous to pose economic damage.

Leaf beetle Lema planifrons

The larvae and adults of this beetle scrape off epidermal tissue from leaves of mainly seedlings where only the leaf veins remain. The crop can normally tolerate high rates of defoliation if it is growing well. If the infestation occurs in the vegetative stage up to 30% leaf area could be tolerated. Late growth stages could tolerate 15% leaf loss without any yield loss.

To monitor, use sweep net sampling: take 10 insect net sweeps per sample while walking through the field. If more than 10 adults collected, or more than 1 per sweep, the field should be sampled weekly to monitor the larval population.

Armyworms Spodoptera exempta, S. littoralis, Mythimna loreyi

Spodoptera spp. are important on sorghum while Mythimna is more prevalent on millet. Both are migratory moths that can descend in large numbers and consequently lay hundreds of eggs in masses, so infestation can build up rapidly in the absence of natural enemies such as parasitic wasps. The larvae pass through five stages and serious damage develops rapidly once caterpillars reach the L4 stage. They prefer to feed on the succulent leaves in the whorl first and usually feeding is confined to leaf margins, although occasionally they may consume all except the main leaf veins.

Outbreaks follow the onset of wet seasons when dry grasslands produce new growth and cereal crops are planted. Their severity and extent is increased by extended drought followed by early season rainstorms. For sampling: examine 20 consecutive plants in at least 5 random locations. Note the number of plants with the characteristic damage and the size of the larvae. Action thresholds for early whorl stage are 200 second (II), 80 third (III), or 20 fourth (IV) stage caterpillars per 100 plants. Apply corrective if larvae are at or above threshold levels and preferably when caterpillars are 12 to 20 mm long.

Grasshoppers/locusts Acrotylus blondeli, Cataloipus cymbiferus, Cryptocatantops haemorrhoidalis, Eyprepocnemis plorans, Schistocerca gregaria

Grasshoppers feed on many species of plants. Some species become migratory where the next generation has longer wings and can disperse afar. For example, the desert locust migrates following wind convergence systems and seasonal rains to areas with abundant vegetation. Grasshoppers cause some damage every year, but they become very destructive during locust outbreaks. Locusts have a high reproductive capacity: female lays an average of 200 eggs per season, and sometimes as many as 400 eggs. The main factor affecting grasshopper populations is weather. Outbreaks, or exceptionally large populations, are usually preceded by several years of hot, dry summers and warm autumns since they increase the survival of nymphs and adults and allow grasshoppers more time to feed and lay eggs. The cereal crops can tolerate significant loss of photosynthetic tissue before yield loss would occur. Feeding on the flowers and developing grains however is more serious, and would require corrective action to be taken.

To monitor populations: count the number of grasshoppers per m². If there are 0-2, the infestation is non-economic; 3-7 it is a light infestation; 8-14 it is threatening; 15-28 it is severe; > 28 it is very severe. For more accuracy, convert the data to adult equivalents. For example, small grasshoppers (< 1.5 cm) are equivalent to 0.5 adults in terms of caused foliage loss.

Millet stem borer Coniesta ignefusalis

The millet stem borer is a moth and its preferred host is millet followed by sorghum and the grass *Pennisetum glaucum*. The severity and nature of damage depends on the planting date and the time of infestation. The stemborer spends the dry season inside the stalks and stubble. As stalks of millet are used as building materials and fodder, they are stored in protected graineries during the off season which results in high survival rates of resting stemborer larvae. There was a two-week lag time between first moth catches and the first rain. Stimulated by the first rains, dormant larvae inside old millet stems awaken to pupate and emerge as adults. The adults disperse and mate and soon lay eggs on the developing crop. Even though field sampling often finds high infestation rates ranging from 35-72%, infested tillers often outyielded uninfested ones. Thus there is scope for compensation of damage. In one study, losses were 25% less in intercropped millet than when monocropped based on damage versus non damaged plants. Loss is worse if the stemborer is feeding during panicle exsertion rather than in later stages in panicle development. Boring pests are particularly difficult to control with conventional insecticides because the larvae spend most of their lives protected by host-plant tissue. When more than 15% of stems show damage in earlier planted fields, chemical treatment is necessary.

Sorghum stem borers Busseola fusca, Eldana saccharina, Sesamia calamistis

The larvae of these three stem borer moths feed on tall grasses and cereals as their body size is large and are more important on sorghum than millet. *Busseola* is more a pest of maize and sorghum but will occur on millet. They are likely to be more abundant around areas where sugarcane and maize are planted, particularly in the dry season under irrigation. They are not abundant in most years. As the damaging stage occurs within the protection of a stem, these stemborers are difficult to control with insecticides. If stemborer damage is noted on more than 15% of stems in earlier planted fields, take corrective action.

Millet head miner Heliocheilus (=Raghuva) albipunctella

The millet head miner is the most important insect pest of pearl millet in the Sahel according to ICRISAT scientists in Niger. Moths deposit their eggs on the heads of millet, preferring half-emerged and fully-emerged flowering heads. The caterpillars mine into the seeds of the millet head, damaging the millet panicle (ie, the flower head, where the grain is formed). It has been reported to cause 40-85% loss and was identified as a

priority pest at the 1993 Consultative Group Meeting on sorghum and millet pests. Together with the millet borer they cause annual yield losses estimated at more than US\$ 207 million. The head miner is more abundant during droughts and it became a major pest during the droughts of 1972–1974. Pupation takes place in the soil and they survive the off-season in the stubble and stalks which farmers keep in their granaries ensuring a high survival of the larvae. Young larvae perforate millet glumes and eat the flowers, whereas mature larvae cut the floral peduncles, thereby preventing grain formation or causing mature grains to spill.

Sorghum midge Stenodiplosis (= Contarinia) sorghicola

Larvae of the sorghum midge feed on the ovary, preventing normal seed development. Sorghum midges overwinter as larvae in aborted sorghum spikelets. They spin cocoons inside the spikelets where they may remain in a resting stage that is resistant to cold and desiccation for as long as 2 or 3 years.

Millet grain midge Geromyia penniseti

The grain midge attacks late millets to cause a considerable loss in yield: 58-98% loss has been reported in some years. Females are active at night laying eggs on flowering stage panicles. The life cycle is short (2 weeks) so 4-5 generations can occur within a season. The larvae pass the dry season in dormancy for 8-9 months, and as the stalks are kept by farmers as silage, high numbers of the pest can survive over the long dry season. When dormancy is broken by rain, the female matures and lays eggs. Infestation is highest when there is an extended range of flowering between different fields stemming from drawn out sowing periods and the use of early and late varieties in a farm community.

Millet flower beetles Rhinyptia infuscate (scarab beetle), Psalydolytta fusca and P. vestita (blister beetles)

Flower feeding insect pests are important on millet. Blister beetles feed during the day on anthers and pollen while the scarab beetle feeds at night. There are some 10 species of blister beetles that feed on millet. Blister beetles are medium to large sized (2-5cm in length) and are black and yellow or black and red in color. The scarab is the more serious pest. Its larvae may also be the white grub pests attacking roots earlier in the season. The root feeding larvae have been found in millet and cowpea fields where populations reached 20,000/ha. The scarab beetle burrows into the soil during the day. Densities per panicle have ranged from 0.3-15 and losses range from 11-38% depending on the year and location.

Seed feeding bugs Dysdercus volkeri, Oedaleus senegalensis, Eurystylus oldi, Creontiades pallidus, Agonoscelis versicolor, Spilostethus spp.

All of the bugs cause similar injury but the key seed pest is *Dysdercus* because it is generally the most numerous. The adults and nymphs have needle-like mouthparts that they inject into developing seeds to remove endosperm that can either abort seed formation if the spikelet is young or reduce seed size. When they feed, they inject enzymes to pre-digest the endosperm and at the same time introduce microbes that cause secondary infections. Up to 50-60 bugs can occur on a single panicle that is usually completely destroyed. Highest populations occur on late flowering fields.

Millet/S	Millet/Sorghum			
Insect	Damage	Available control measures	Pesticides	
Pests/				
mites				
White	Damages roots. Larvae feed on	-Thorough tillage to expose larvae.	Imidacloprid seed	
grubs	roots underground and can	-Increase the seeding rate.	treatment or soil drench	
(Vers	remove all of them, killing young	-Use of compost instead of raw	with a sprayable	
blancs)	plants. They can be found in the	manure.	formulation.	
	root zone.	-Remove grassy weeds.		
		- Spreading small heaps of raw	Seed treatment:	
		manure where the grubs will	thiamethoxam, mefenoxam,	
		gather to multiply in these heeps	and difenoconazole.	
		and further spraying insecticides on		

		these heaps would eventually destroy themInstollation of solar lamps on field to attract adult insects.	The most effective time for application of imidacloprid could be from the month preceeding egg hatch until the grub hatch. The efficacy of Imidacloprid declines with the grub development. It is better to apply Imdidacloprid as a preventive approach. Application of neem cake.
Wirewo rms (Ver fil- de-fer)	Cut off small roots or tunnel into the root or stem of young plants. Seeds that don't germinate. Plants are stunted or wilted with the whorl leaves wilting first. Thin stands.	-Same as for white grubs.	Same as for white grubs.
Shoot fly (Mouch e des pousse s)	The fly maggots feed on the inside of young stems causing them to wilt and die.	-Early plantingSynchronous planting between fields in a communityGood nutrient managementThe Introduction of larval parasite <i>Telenomus spp</i> could effectively control this insect.	Imidacloprid 25% seed treatment. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole. ULV deltamethrin, lambda cyhalothrin, or dimethoate in severe infestations only. Once the infestation has begun, no insecticides will be bery effective. Application of neem cake or neem seed kernel extract also found to be effective on larvae of shoot fly as neem has ovicidal Properties.
Spittle bug (Cercop es)	Reduced plant vigor, death of seedlings and wilting of mature plants. Froth can be found on the plants which resembles spit.	-Good nutrient management of the cropWeedingApplication of neem cake with green manure could avoid the spread of this insect.	
Leaf beetle (Chryso mèle)	Defoliation. Leaves can appear white. Larger leaf veins are not consumed leaving a skeletonized appearance.	-Good nutrient management of the crop.	Neem seed extract.

Armyw orms (Légion naires)	Most defoliation occurs on young plants which can be killed.	-Hand remove egg massesRemove weeds early in the crop.	Bacillus thuringiensis, fire ash, chili peppers, neem seed extract, chloranthraniliprole EC, flubendiamide SC, or nuclear polyhedrosis virus (SpexNPV). A bait which is a mixture of cane sugar + brown rice + pesticide could effectively control Armywarm infestation as the larvae are attracted towards the sugar and die after consuming the
Grassh opper/l ocust (sauter elle/cri quet)	Feed on all parts of the plant causing various degrees of defoliation but swarms of locusts often leave only bare stems.	-Thrashing the crop with sticks or waving flags and beating drums to make them fly elsewhereTill fields to curtail egg layingRemove weeds.	and die after consuming the pesticide. Acetamiprid EC, beta cypermethrin, or malathion. Spraying neem seed kernal extract makes the leaves inpalatable and the grass hoppers do not prefer to eat it. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: beta cypermethrin and malathion.
Millet stembo rer (Foreur de tige du mil)	Destruction of the tillers of millet plants and premature plant death (deadhearts) when early season attacks. Reduction of number of stems and panicles Attack on older plants causes disruption of nutrient flow, stem lodging and poor or no grain formation.	-Good nutrient management: microdosing of a cap-full of diammonium phosphate and a hand full of compostPlant resistance.	Spray individual panicles when they first emerge with chloranthraniliprole EC, spinosad, or neem.
Sorghu m stembo rers (Foreur du Sorgho)	Presence of excreta, holes in the stems, and the presence of deadhearts which often results in profuse tillering and unproductive tillers. Late attack may result in extensive stem tunneling, the production of chaffy panicles, and panicle breakage.	-Plant early at the beginning of rains or within 2 weeksMicrodosing of a cap-full of diammonium phosphate and a hand full of compostEarly planting (appropriate planting dates should be deciced based on local infestation levels)Removal and destruction of deadhearts and alternate host plants.	Spray individual panicles at panicle exsertion with chloranthraniliprole EC, spinosad, or neem.

Millet head miner (La chenille mineus e de l'épi)	Damaged panicles. Young larvae perforate millet glumes and eat the flowers, whereas mature larvae cut the floral peduncles, thereby preventing grain formation or causing mature grains to spill.	-IntercroppingBiological control with Trichogramma Use of sex pheromone trapsEarly maturing variety and plant earlyTolerant variety (such as varieties with long bristles)Mass rearing and release of a larval braconid parasite Spray individual panicles when noted on more than 15% of panicles in earlier planted fields.	Chloranthraniliprole EC, spinosad, or neem.
Sorghu m midge (La Cécido myie du sorgho)	Destroyed grains. Infested heads appear blighted or blasted and produce small, malformed grain.	-Early plantingResistant varietyPlant so that all fields flower within 10-15 days.	Chloranthraniliprole EC, Spinosad, or neem. When noted on more than 15% of panicles in earlier planted fields, spray individual panicles.
Millet grain midge (Cécido myie du Millet)	Destroyed and unformed grains. White, empty pupal cases can be found clinging to the tip of spikelets.	-Synchronize planting so that all varieties flower at the same time.	Chloranthraniliprole EC, spinosad, neem. When noted on more than 15% of panicles in earlier planted fields spray individual panicles.
Millet flower beetles (Coléop tères de la fleur du millet)	Beetles feed day or night on developing flowers and grains	-Synchronize planting so that all varieties flower at the same timeCollect adult beetles with hand nets and feed to chickens; however, care should be taken with blister beetles as they release a liquid that burns the skinUse varieties with long bristlesUse of fires to repel <i>P. fusca</i> from spikes with a heavy smoke producing fuel (groundnut shells, moist wood).	Spray individual panicles with chloranthraniliprole EC, spinosad, or neem. Spray individual panicles when they are noted on more than 15% of panicles.
Seed- feeding bugs (Insecte s suceurs de la graine)	Nymphs and adults feed on developing grains and cause distortion, shrinkage and shriveling of the grain.	-Synchronize planting so that all varieties flower at the same time.	Spray individual panicles with chloranthraniliprole EC, spinosad, or neem. Spray individual panicles when noted on more than 15% of panicles in earlier planted fields.

Stored product insect pests

Stored grains of pearl millet and sorghum are attacked by insect pests. The main species are rice weevil *Sitophilus oryzae*, maize weevil *S. zeamais*, Angoumois grain moth *Sitotroga cerealela*, Indian meal moth *Plodia interpunctella*, the lesser grain borer *Rhyzopertha dominica*, and the confused flour beetle *Tribolium confusum*. For this reason, the popular concept that millets are hardly susceptible to damage by storage insect pests is erroneous. The first three storage pests are probably of greatest importance because they can infest whole grains and infest first in the field. Protection of stored products at the farm level is distinct from food storage by USAID partners in warehouses before distribution to beneficiaries.

Nigerien farmers usually use a mixture of clay or mud and chopped straw called 'banco' to build underground and sealed granaries. Such granaries can be four cornered, spherical, with a straw roof containing a protected lid or in the shape of a cone with the tip pointed downwards and resting on a foundation of stones. Grain inside these 'banco' granaries is well protected against rain and the invasion of insects and is kept viable for germination. In fact, if the structure is well built and maintained, insect pests would find it hard to survive due to lack of oxygen. However, 'banco' granaries require good maintenance, such as filling cracks with mud structures sealing holes and fissures and thorough cleaning. Other method used are stated in the table above. However, despite all of these methods losses from stored insect pests remain high. Therefore, farmers should test the triple plastic bag storage method (see cowpea bruchids) if their local practices are not sufficient.

Millet/Sorghum	Millet/Sorghum			
Stored Product	Damage	Available Control Measures	Pesticides	
Insect Pest				
Stored grain insect pests at farm level	Total destruction if not controlled	-Storing in sealed and underground granaries (using 'banco')Storing in sealed drumsHanging millet heads over kitchen fires to repel storage pests with the smoke Storing millet by whole panicles to reduce damageMix seeds with inert substances, such as sand and wood ashMix seeds with plant materials such as leaves of <i>Boscia senegalensis</i> , mint <i>Hyptis</i> sp., or pulverized chili pepperTriple bagging to remove air.		

Diseases

Diseases are mostly low incidence in traditional systems due to genetic resistance and cultural practices. The three most important diseases of cereal crops are downy mildew, smut and ergot with downy mildew being the most severe. Smut and ergot are normally of minor importance but can become serious in some cases based on area, environment and genotype. Early sown fields escaped high incidence of the three pathogens whereas yield loss on late sown fields was about 75%.

Damping off fungi Exserohilum turcicum [Setosphaeria turcica], Pythium spp. Rhizoctonia spp.

Fungal diseases of seeds and seedlings are more prevalent when seed is planted in waterlogged soils, especially when rains cause a crust to form on the soil surface. Seedling emergence and growth is slowed under such conditions, and several soil-borne fungi are able to infect the tender seedlings. Other factors such as poor seed

quality often contribute to the problem. Continuous growth of one crop over a period of years may favor buildup of organisms that cause seedling disease. Damping off is the symptom of wilted seedlings exacerbated by heavy soils.

Charcoal rot Macrophomina phaseolina

This fungus is an important pathogen of crops particularly where high temperatures and water stress occurs during the growing season, when the maize stalks begin to senesce. Grain sorghum plants affected by the charcoal rot fungus fail to fill grain properly and may lodge in the latter part of the season. *M. phaseolina* survives as resistant spores, produced in the host tissue and that are released in the soil or remain on infected plant debris. These are black, spherical to oblong structures that serve as the primary source of inoculum and have been found to persist up to three years in the soil.

Gray leaf spot Cercospora sorghi

This fungal pathogen is more common in humid regions. Losses associated with gray leaf spot occur when photosynthetic tissue is rendered nonfunctional due to lesions and/or the blighting of entire leaves. The blighting and premature death of leaves severely limits radiation interception as well as the production and translocation of photosynthate to developing kernels. This is especially true for the upper eight or nine leaves, which contribute 75 to 90% of the photosynthate for filling grains.

Sorghum leaf blight Exserohilum turcicum

Most African sorghum varieties are resistant to leaf blight but early maturing varieties are more damaged. The fungus is present on the seed and in the soil with secondary infection emanating from wind born spores especially in high humidity (90 %) and high rainfall.

Bacterial stripe disease Burkholderia (= Pseudomonas) andropogonis

In general, the disease is of minor importance on sorghum. However, as it is a bacterium, there are few products that can curtail this disease.

Anthracnose Colletotrichum graminicola

Anthracnose is an important fungal leaf and stem blight of sorghum. It is favored by moist weather with frequent rains and damages foliage and stems of grain. When infected stems are cut lengthwise with a knife, one can see that the fungus has penetrated the soft pith tissue and caused brick-red discolorations. This peduncle infection inhibits the flow of water and nutrients to the grain causing poor grain development. The fungus also invades individual grains and the small branches of the panicle. Rapid and severe yield loss can result from panicle and peduncle infections.

Downy mildews of pearl millet Sclerospora graminicola and sorghum Peronosclerospora sorghii.

Downy mildew is considered as the most serious disease of millet. A different species affects sorghum. The disease is prevalent during rainy seasons. Low organic matter, low pH and low loam content of the soil as well as sandy soil predispose the crop to greater disease infection. The disease can be serious in some years. Spores, which are the source of primary inoculum, remain in the soil and infect the underground parts of plants, mostly at the seedling stage. Normally, crop losses are of 0-20% but up to 50% have been reported. Crop residue incorporated into the soil provides a continuous inoculum source in areas where no crop rotation is practiced.

Ergot Claviceps fusiformis

Ergot is a fungal disease of pearl millet that affects the panicles. Spores are spread from plant to plant by wind, rain splash, and insects. An overcast sky, drizzling rain (>80% relative humidity), moderate temperatures (20-25°C) and air movement during crop flowering favor the development and spread of ergot. Wild species of *Pennisetum* and related grasses are hosts that may serve as reservoirs of inoculum. Seed contaminated with the spores play a major role in the spread of the pathogen. Ergot infection can have a significant impact on yields, with up to 70% loss in susceptible varieties. Honeydew oozes out of the infected florets 5-7 days after infection. The honeydew contains numerous spores that serve as secondary inocula for the disease. Two groups of alkaloids have been identified in the spores that are toxic to humans and animals that feed on

diseased grain. Symptoms of ergot poisoning in animals and man are giddiness, diarrhea, nausea and vomiting, followed by dehydration.

Rough leaf spot Ascochyta sorghi

Spores are spread primarily by rain splashing soil on the stem but physical contact by field workers could serve as another method of spread, particularly when the leaves are wet. Symptoms on sorghum occur in leaf blades and sheaths, peduncles, and stalks. No fungicides have been found that can control the disease.

Long smut Tolyposporium ehrenbergii

The pathogen can only infect up to 10% of grains. Immature, green fungal bodies called sori are larger than the seed develop on panicles during grain fill. A single fungal body (sorus) develops per floret. As grain matures, sori change in color from green to dark brown and are filled with dark spores. Infection takes place at temperature range of between 21 and 31°C, and at relative humidity greater than 80%. The disease is spread by wind-borne spores and rain.

Covered kernel smut Sporisorium sorghi

Usually, all of the kernels in a smutted head are destroyed and replaced by dark brown, powdery masses of smut spores where the whole head is covered by a membrane that usually ruptures at harvest time. Smut spores adhere to the surface of healthy seeds where they contaminate next year's seed. These infected grains are toxic to people.

Loose kernel smut Sphacelotheca cruenta

This fungal disease is transmitted by infected seeds and by air movement. Galls formed by loose kernel smut are long and pointed and the thin membrane covering them usually breaks soon after galls reach full size.

Head smut Sporisorium holci-sorghi (= reilianum)

This smut has a limited effect in causing yield loss. TWind and rain quickly scatter the smut spores to the soil and plant debris, where they live through the dry season. Plants become infected while in the seedling stage but evidence of infection is not apparent until heading time. Different races of the fungus exist which may result in a sorghum variety being resistant in one area but not another.

Disease	Damage	Available Control Measures	Pesticides
Damping off	Seedlings wilt and die. Seed decay,	-Clean seed.	If damping off is a
fungi	pre-and post-emergence damping	-Plant on ridges.	perennial problem
(Fonte des	off, stem lesions on seedlings, or	-Wide spacing.	or soils are heavy,
semis)	stem canker on more mature plants.	-Avoid water stress by planting early.	apply seed
·	Sometimes banding pattern. Dead brown leaves around the base of	,	treatment.
	mature plants. Root systems are		Seed treatment:
	reduced with extensive killing and		thiamethoxam,
	discoloration.		mefenoxam,
			and difenoconazole
			Seed treatment:
			mancozeb, thiram.
			Seed treatment:
			thiamethoxam,
			mefenoxam,
			and difenoconazol

			T
			Neem cake application to nursery and main field, as well. Fluopicolide, fosetyl-aluminum (soil drenches to be sprayed into the soil in high water volume).
Charcoal rot	Seedling blight, root rot, and	-Clean seed.	Fungicides are not
(Pourriture charbonneuse)	charcoal rot symptoms. Production of black resistant spores in the vascular tissue and inside of the stalk. The stalk is gray to black and shows an internal shredding at and above the ground line.	-Tolerant varietyRemove field plant residues after harvestDeep tillage to bury sporesIntercroppingCrop rotation Wide spacingBalance nitrogen and potassium fertility levels.	effective.
Gray leaf spot (Maladie des	First symptoms on the leaves are small dark lesions which are oval in	-IntercroppingCrop rotation.	Mancozeb (most effective at 120
taches rectangulaires)	shape but may be oblong or rectangular. The centers of the	-Remove plant residues after harvestRemove adventitious weedy grasses.	grams/liter without much photoxicity).
	lesions are gray to tan with black spots. Lesions also occur on the stems.	-Avoid highly susceptible varieties.	Azoxystrobin (most effective at 1, 2 and 4 ml/liter, and optimally at 2 ml/liter without phytotoxicity)
Sorghum leaf blight	Seed rot and seedling blight. Small narrow elongated spindle shaped	-IntercroppingCrop rotation.	Thiram or mancozeb.
(Helminthospo riose)	spots in the initial stage, whereas, on older plants, spots extend along the length of the leaf becoming bigger	-Resistant varietyDisease-free seeds.	muncozes.
	elliptical necrotic lesions, straw colored in the center with dark margins. Burnt appearance of the crop and drying of leaves.		
Bacterial stripe disease (Raies	Long narrow stripes that vary from red to black. Initial symptoms are	-IntercroppingCrop rotation.	Bactericides are ineffective.
bactériennes)	small, linear, interveinal lesions. Bacterial exudate is usually observed on infected portions of the leaf. Lesions may also occur on the kernel, peduncle, rachis branches and in the	-Crop rotationSow clean seed by selecting it from healthy plantsRemove plant residues after harvest.	menecuve.
	interior of the stalk. These stripes		

	are confined between the veins and		
	may have a crusty surface.		
Anthracnose	Red and purple coloration first	-Intercropping.	If it is a common
(Pourriture	occurs on leaves, then on stems and	-Crop rotation.	disease treat seed.
rouge)	the inside surfaces of stems. The	-Clean seed.	
	stem holding the head (peduncle)	-Resistant variety.	Seed treatment
	might become infected and a brown	-Remove plant residues after harvest.	with
	sunken area with distinct margins		mancozeb or
	develops.		thiram (2.5 gr/kg of
			the seed found to
			be more effective
			and does not
			impact
			germination).
			Seed treatment:
			thiamethoxam,
			mefenoxam,
			and difenoconazole.
			Seed treatment
			with neem oil 1
			ml/liter.
			Seed treatment:
			thiamethoxam,
			mefenoxam,
			and difenoconazole.
			Spraying neem oil at
			3 ml/liter.
Downy	Chlorosis starting at the base of a	-Intercropping.	Fluopicolide or
mildews of	leaf until the entire leaf is chlorotic.	-Disease free seed.	fosetyl-aluminum.
sorghum	Severely infected plants are barren	-Resistant variety.	
(Mildiou du	and produce malformed heads, so	-Roguing within the first month after	Seed treatment (for
Sorgho) and	called 'green ears' or 'crazy tops'.	sowing to give a result.	endemic areas)
pearl millet	Yield loss is due to complete or	-Bury infected plants.	metalaxyl and
	partial conversion of florets to leafy	-Crop rotation.	carboxin.
	structures instead of grain ('green ear').	-Early sowingImproved crop nutrient fertilization.	Foliar application of
	ear j.	-Deep tillage.	metaxyl.
		-Avoid growing highly susceptible grain or	incturyi.
		forage sorghum.	Seed treatment:
			thiamethoxam,
			mefenoxam,
			and difenoconazole.
			Application of 3 ml
			neem oil mixed with
			starch is found to be
			effective on downey
			mildew, as well.

Egot	Fungal spores infect and replace developing grains on the head of millet. Infected grains turn into a dark brown hard sack of spores called a sclerotium. Dark sclerotium: a fruiting structure found replacing the grain in the heads of millet just prior to harvest.	-IntercroppingClean seedDeep-plow fields which have a severe ergot infestation by burying the sclerotiaAdjustment of sowing datesJudicious application of fertilizers.	No fungicides can control the disease.
Rough leaf spot (Maladie des grains de sable)	Small, reddish, discoloured lesions on leaves that then become broad-elliptic. Uniformly dark red to purple or tan centre with a dark red to purple border. Entire leaves may die, turn brown and become covered with spores. On sorghum symptoms can occur in leaf blades and sheaths, peduncles, and stalks.	-Resistant varietyCrop rotationRemove plant residues after harvest.	No fungicides can control the disease. Neem oil spray could arrest the dissemination of spores and partially controls the disease.
Long smut (Charbon allongé du sorgho)	Fungal spores grow in single florets destroying grains	-Remove and destroy recently infected paniclesRemove alternate hosts.	Seed treatment is not effective.
Covered kernel smut (Charbon couvert du sorgho)	The fungus destroys all kernels in a head and replaces them with a coneshaped gall	-Rouging infected paniclesRemove crop residues and infected paniclesClean seed.	Seed treatment mancozeb, thiram, metaxyl and carboxin, or imidacloprid. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
Loose kernel smut (Charbon nu)	Galls are formed. Normally, all kernels in an infected panicle are smutted. Partial destruction is rare.	-Rouging infecting paniclesRemove and destroy recently infected panicles and crop residuesClean seed.	Seed treatment mancozeb or thiram. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
Head smut (Charbon de la panicule)	Large, dark-brown smut galls emerge in place of the panicle. The gall is first covered with a whitish membrane that soon breaks and frees the spores. The head may be totally smutted with characteristic "witches' brooms," i.e., many small, rolled leaves protruding from the heads of suckers. Some cultivars are dwarfed; others are stunted due to a lack of elongation of the peduncle.	-Rouging infected paniclesRemove and burn head smut galls before the spores are scatteredUse resistant varietiesGrow sorghum in the same field only once in 4 years.	Seed treatment mancozeb or thiram. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.

Birds

Red-billed quelea Quelea quelea

The quelea is the world's most abundant wild bird species, with an estimated adult breeding population of 1.5 billion pairs. Millet is more susceptible to bird damage that sorghum. The amount of loss they cause is about 5% of the cereal crop annually, but damage is uneven with most farmers escaping loss while some unlucky others will lose their whole crop. Quelea birds attack in large sky-blackening flocks. On average, one bird eats around 10 grams of grain per day so a flock of two million can devour as much as 20 tons of grain in a single day. Reducing their numbers is highly problematic - they are highly mobile, have few natural predators, and breed extremely fast (one pair of quelea birds can produce up to nine offspring annually).

Despite the annual destruction of millions of quelea birds by use of pesticides, damage has continued to increase annually. The most common way of controlling the pest is by large-scale spraying of infested areas by Plant Protection Departments. The Plant Protection Department staff is trained to use Fenthion 640 ULV but farmers should not attempt to use this toxic insecticide cum avicide.

Millet/Sorghum			
Bird	Damage	Available Control Measures	Pesticides
Red-billed	Attack crops near harvest. Can	-Scare the birds by making noise or	None.
quelea	totally remove all of the grain.	banging during the month before harvest.	
(Travailleur à		-Use tolerant varieties (such as with long	
bec rouge)		bristles).	

Weeds

Striga parasitic weed Striga hermonthica

Striga, commonly known as witchweed, is a genus of parasitic plants. Striga occurs on roots and requires a living host for germination and initial development, though it can then survive on its own. Maize, sorghum, and millet are the most important hosts. Each Striga plant is capable of producing up to 50,000 seeds and the small dust-like seeds can live in the soil for over 20 years. The high reproductive capacity means that a minor infestation can lead to devastating levels of damage in only a few seasons: severe infection can cause 20-80% crop loss in maize even leading to total crop failure. Farmers often abandon infested agricultural lands as a result of high soil infestation. Striga seeds germinate in the presence of host root exudate, and the parasite then is stimulated to penetrate roots of millet and sorghum. It causes serious damage to its host crop before emerging from the soil by producing phytotoxins which are harmful to the host crop. Upon attachment to host roots, it withdraws photosynthate, minerals and water, resulting in characteristic "witch" appearance of the host crop manifested by stunting and withering. Striga emerges from the ground after 6-12 weeks and produces bright purple flowers that eventually bear seeds. Witchweed seeds spread easily on people's clothes, wind, water, and soil via cattle. Subsistence farmers who cannot afford expensive witchweed controls, and therefore suffer much as a result of this pathogen grow the majority of crops in Africa. Striga thrives best in poor soils in areas prone to drought such as in Niger.

Millet/Sorghu	Millet/Sorghum			
Weed Pests	Damage	Available Control Measures	Pesticides	
Striga	Symptoms are stunting,	-Hoe weeding and hand pulling.	No herbicide is	
parasitic	wilting, and chlorosis and	-Application of inorganic fertilizer and manure.	effective.	
weed	are similar to those seen	-Micro-dosing nitrogen and phosphorous.		
	from severe drought	-Fallowing.		
	damage, nutrient deficiency,	- Early planting.		
	and vascular disease.	-Tolerant/resistant variety.		

-Intercropping with cowpea as a trap crop (5 rows of	
millet and 5 rows of cowpea and the following year,	
reverse the crops on the same land).	
-Crop rotation with a legume or sesame.	
-Improving soil nutrient levels.	
-Use of video produced by ICRISAT – available in	
Hausa, Zarma and many other languages – proven to	
be a highly effective training tool.	

GROUNDNUT

Originally, groundnuts came from southern Bolivia and northern Argentina, where the local Indian peoples cultivated them. Then the groundnut was "discovered" by Spanish explorers and spread throughout the world, including Africa. Africa produces 20% of global production of groundnuts, concentrated in the semi-arid tropics especially Niger, Nigeria, and Mali, being a favorable source of nutrition and cash earnings in semi-arid zones. Groundnut is a cash crop, protein and oil source, has high energy value and provides 13 different vitamins, and 26 essential minerals. It is eaten boiled, fried, roasted, or as a sauce for local cuisine. Major constraints are drought, disease, insect pests, including soil pests. Groundnut production in Niger — as a cash crop — dropped from about 312,000 tons in the mid 1960s (about 68% exported) to as low as 13,000 tons in 1988 and increased again to 110,000 tons in 2000. Since then the situation has changed, groundnuts have to be supplemented by imported food to meet the country's needs.

Yields are low, 0.95 metric tons a hectare, compared to 1.8 metric tons a hectare in Asia, and an average global yield of 1.56 metric tons a hectare. One of the main reasons for low yields and poor quality is drought. Groundnut is typically grown in the wet season as an intercrop with millet and sorghum. Farmers like groundnut because it is a food and cash crop; does not require fertilizer; well adapted to the area. One reason for low yields is the susceptibility of currently grown cultivars to groundnut rosette disease, the most destructive disease of groundnut.

Insect Pests

Soil insect pests

Termites, white grubs, millipedes, wireworms, and false wireworms are the major groups of soil pests affecting groundnut production in sub-Saharan Africa. Farmers' cultural practices such as improper application of organic manure rather than compost, leaving crop residues in the field, delays in planting and harvesting, and abiotic factors such as rainfall and soil texture also exacerbate soil pest occurrence and damage. Termites (*Microtermes* sp. *Odontotermis* sp.) attack the crop in all stages and losses are higher during a drought from injury the crop through constructing foraging galleries. Older and larger white grub larvae chew off roots that reduces water absorption capacity leading to stunting and death. Underground pods also may be damaged. Secondary infection often is by damping off fungi. Millipedes (*Peridontopyge* spp.) feed on cotyledons and then root system at the collar region. They refer young seedlings (< 15-d-old) averaging losses from 3-5% and an additional 5-10%, as a result of secondary infections. Wirerworms and false wireworms (tenebrionid *Zophosis* sp.) feed on immature and mature nuts in the soil.

Grasshoppers/locusts Acrotylus blondel, Cataloipus cymbiferus, Cryptocatantops haemorrhoidalis, Eyprepocnemis plorans, Schistocerca gregaria

Grasshoppers pass the dry season in the egg stage and the hoppers hatch at the onset of the rains in June and July. Fledging occurs from July to October, breeding and egg laying occur from September onwards. Egg pods, each containing 80-100 eggs, are laid in shade, often on abandoned agricultural fields. They are not gregarious

and morning and late afternoon flights are made to farmland from the surrounding habitat for feeding. The preferred food is millet, of which both the leaves and the immature seed-head are eaten, at the 'milky grain' stage only the grains are taken from the head. It is the 'milky grain' stage which is primarily attacked because it is ideal food and tends to occur at about the time when grasshoppers are in the late hopper or fledgling stages. Once a millet crop is destroyed or too mature, grasshopper populations move on to legumes such as groundnut where the foliage is eaten; sorghum and groundnut may also be attacked in areas with no millet or cowpea.

Armyworm Spodoptera littoralis

Armyworm moths migrate following wind convergence systems and seasonal rains to areas with abundant vegetation. Worms feed on leaf tissue causing groundnuts to look ragged and larvae can defoliate late maturing peanuts rapidly. Young larvae are pale green to yellow in color while older larvae are generally darker green with a dark and light line running along the side of their body and a pink or yellow underside. The insect can go through 3–5 generations a year. Research has shown that one-third of groundnut foliage can be lost before flowering without loss of yield.

To determine if treatment is needed, select a sample 3 meters along a row (3 m-row sample) in five locations in the field, shake the foliage vigorously and count the worms on the ground. Repeat the sample in four more locations. Treatment is recommended if an average of 8 or more worms is found per 3 m-row sample.

Cowpea aphid Aphis craccivora

Cowpea aphid is a relatively small aphid and the adult is shiny black while the nymph is a dull gray. The hind appendages are usually whitish with blackish tips. While feeding, the cowpea aphid produces a considerable amount of honeydew upon which sooty mold grows further blocks photosynthesis. Its main role on groundnut as a pest is a vector of rosette virus.

Beginning three weeks after crop emergence, scout 20 plants chosen randomly walking through the field. Determine how many plants have aphids and count the aphids per plant after shaking them onto a cloth. The decision threshold for treatment is when populations are 250 aphids per plant, when at least 80% of the plants are infested, and the population is still increasing. Stop sampling once groundnuts have matured as losses will no longer be significant.

Leafhopper Empoasca

This small, wedge-shaped, insect is light green to yellow. Both adults and nymphs insect feed on the groundnut plant from the undersides of leaves in a piercing-sucking manner as phloem feeders. During feeding, toxins also are passed into plants at feeding sites that can stop vine growth, resulting in reductions in yield and grade. Damage is worse when plants are stressed. It is important to note that although late-season damage appears worse in some years, damage done early in the season probably has a greater effect on plant vigor and yield. Scout weekly from 20 randomly chosen plants throughout the field. When 20 percent of the leaves show tip yellowing typical of leafhopper damage and active adult and immature leafhoppers are seen, treat with an effective chemical.

Thrips Frankliniella sp., Sericothrips sp

Thrips are small (1.5 mm long) and spindle shaped insects that are best viewed using a hand lens. Adult thrips are pale yellow to light brown and the nymphs are smaller and lighter in color. They possess rasping-sucking mouthparts that they use in tearing tender leaf surfaces for removal. They are often found on groundnut blooms and between folds of young leaflets in plant terminals. In addition, thrips also transmit viruses to plants, including tomato spotted wilt virus and peanut bud necrosis virus.

Beginning three weeks after crop emergence, sample 20 randomly selected plants each week. Foliar treatment is recommended when 25 percent of the leaves show thrips damage and pest populations are still active.

Pod borer/tomato fruitworm Helicoverpa armigera

Pod boring caterpillars are 12-20 cm long and of various shades of brown and green, with a stripe running along their sides. They have stiff bristles in each abdominal segment that differentiate them from cutworms and armyworms. *Helicoverpa* is less damaging in peanuts than other legume crops but high populations can inflict significant damage. The consumption of flowers and pegs during podding can reduce crop potential. In water-stressed crops, terminals are more attractive to larvae than wilted leaves. Vigorously growing plants with adequate available moisture are better able to replace damaged leaves and compensate for flower and pod damage.

Sample weekly during vegetative, flowering and pegging stages with a beat sheet. Sample five 1-metre lengths of row at six locations across the field. Control larvae if threshold of 12 larvae/m² is reached in the vegetative stage. Threshold for flowering and pegging stages is 3-5 larvae/m², the higher value applying to well-watered crops.

Pod sucking bugs Rhyparochromus littoralis, Elasmolomus (= Aphanus) sordidus

These seed bugs (Lygaedae) feed on developing groundnut pods in the field, and later in storage. They are also pests of sesame. Both nymphs and adults feed on the oil in the seeds. In the field, the females lay their eggs in the soil or on groundnut stems, and in storage, eggs are laid loosely among the groundnut or on sacks. The bugs feed on pods left to dry in the field or on stored pods. In storage, this bug feeds on seeds, perforating the pod with their stylet. In case of severe infestation, the produce is unfit for seed as well as human consumption.

They would be very difficult to control in the field as they burrow underground that in the light soils of Niger would allow them entry. In storage, they can be readily controlled.

Groundnut				
Insect Pests/Mites	Damage	Available Control Measures	Pesticides	
Soil insect pests Termites (termites), white grubs (vers blancs), millipedes (mille-pattes), wireworms (ver fil-de- fer), false wireworms	Feed on sown-seed and the germinating seedling as well as roots of older seedlings. Other: damage of underground pods, cotyledons and immature/mature nuts in	-Deep plowingOverseedingCrop rotation.	Imidacloprid seed treatment or if the pest becomes a problem on the growing crop, soil drench with a sprayable formulation.	
(faux ver fil-de-fer)	the soil.		Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.	
Grasshoppers/locusts (sauterelles/criquets)	Feed on all parts of the plant causing various degrees of defoliation but swarms of locusts often leave only bare stems.	-Thrashing the crop with sticks to make them fly elsewhere. -Till fields to curtail egg laying. -Remove weeds.	Acetamiprid EC, beta cypermethrin, or malathion.	
Armyworms (Légionnaires)	Singular, or closely grouped circular to irregularly shaped holes in foliage; skeletonized leaves; shallow, dry wounds on pods. Egg clusters of 50-150 eggs may also be present on the leaves covered in a whitish	-Hand remove egg massesRemove weeds early in the cropMarigold trap crop to attract adult moths where they lay egg in masses which could be	Bacillus thuringiensis when the worms are small. Neem seed extract, chloranthran-iliprole EC, tebufenozide, or nuclear polyhedrosis virus.	

Cowpea aphid (Puceron du niébé)	scale which gives the cluster a cottony or fuzzy appearance. Sometimes consumption of the whole leaf, veins, as well a feed on pegs. Aphid injects a toxin while feeding which can stunt the plant, sooty mold on excreted honey can cover leaves to block photosynthesis. Stem, petioles, terminal shoots, flowers and pods are also	easily collected and destroyedLight traps (solar). -IntercroppingResistant varietySynchronous plantingEarly plantingBalanced plant nutrition.	Bait with sugar and brown rice mixed with pesticide. Chilli-garlic extract (3 kg green chillies and 1/2 kg garlic extract after griding. Add 75 grams detergent per acre). Deltamethrin, lambda cyhalothrin, dimethoate, Horticultural oil, spirotetramat, pymetrozine, laundry soap, neem seed extract, imidacloprid, or acetamiprid.
Leafhopper (Cicadelle)	eaten. Small spots on leaves caused by stippling. The injured leaf margins turn yellow then brown and tend to curve downward known as the "hopper burn". Reductions in yield and grade.	-IntercroppingResistant varietyBalanced plant nutrition.	Laundry bar soap, neem seed extract, imidacloprid, or acetamiprid.
Thrips (Thrips)	Stippling damage on the leaves, they may appear silvery and speckled with black feces. Distortion and curling of leaves and buds, retarded crop growth.	-Intercropping.	Horticultural oil, spirotetramat, and laundry bar soap. Neem seed extract, spinosad, imidacloprid, or acetamiprid.
Pod borer/Tomato fruit worm (Foreur de la gousse)	Larvae chew holes in foliage and initially feed in plant terminals, then blooms, older leaves, and finally pegs as the worms mature	-Intercropping.	If young larvae, then use Bacillus thuringiensis or neem seed extract. If older larvae, use chloranthraniliprole, methoxyfenozide, or indoxacarb. Tebufenozide, deltamethrin, lambda cyhalothrin, or dimethoate.
Pod sucking bugs (Insecte suceurs de la gousse)	Attack pods and kernels (seeds). Seeds shrivel and get a rancid flavor. The infested pods are discolored and show oily spots on the outside.		Imidacloprid EC soil drench.

Diseases

Damping off fungi Aspergillus niger, Rhizoctonia solani, Rhizopus stolonifer, Fusarium sp, Pythium aphanidermatum, Sclerotium rolfsii

Rotting of the seed or germinating seedling in the ground often escapes attention and poor stands are frequently erroneously attributed to inferior seed. It is especially present after weeding. The disease is exacerbated by water logging usually after heavy rains on heavy soil.

Leaf spot fungi Cercospora arachidicola, Phaeoisariopsis personata

Groundnuts can suffer from early and late leaf spot fungal diseases. Both fungi are capable of producing tremendous numbers of spores on infected plant parts. High humidity and warm temperatures favor disease emergence and spread of the disease is promoted by prolonged leaf wetness. Wind, splashing rain, and insects spread spores. Leaf spot can increase rapidly under favorable conditions, as several secondary cycles may occur per season. Abundant peanut residue in fields where peanuts are cropped continuously often results in early and rapid development of leaf spot.

Monitor the crop weekly. If the infection rate is reducing photosynthetic area by 10%, spray a sulfur containing fungicide.

Bacterial wilt Ralstonia solanacearum

Bacterial wilt is the only important bacterial disease of groundnut. It is a serious problem in major groundnut-producing areas, especially in warm humid areas. It affects individual plants from the soil and enters the roots from wounds made by nematodes. Wilt symptoms can be seen 2-3 weeks after planting.

Control of bacterial wilt in infested soils is difficult and there are no pesticides that can control this pathogen.

Groundnut rust Puccinia arachidis

Groundnut rust is highly specific to groundnuts, found on six week or older plants. The fungal disease emergence and spread are favored by warm temperatures and nighttime condensation on the leaves. The disease appears as minute spots or flecks on both sides of the leaf. As the number of infections increase and become older, leaves get a "rusty" yellow color. Infections may also develop on stems and leaf petioles. The severely infected leaves wither and drop prematurely.

Rosette virus

The rosette virus is the most destructive disease of groundnut in Africa and is endemic to sub-Saharan Africa. Although rosette epidemics are sporadic, yield losses approach 100% whenever the disease occurs in epidemic proportions. The disease is transmitted by an aphid *Aphis craccivora* within 3-10 minutes of feeding, in a persistent, circulative manner. Two main forms of the disease: chlorotic rosette and green rosette have been described, based on symptoms. The disease is caused by a complex of three agents: groundnut rosette virus (GRV), its satellite RNA (sat RNA), and groundnut rosette assistor virus (GRAV). Sources of resistance to rosette were first discovered in 1952. These sources formed the basis for rosette resistance breeding programs throughout Africa and have contributed to the development of several high-yielding, rosette-resistant groundnut varieties. There needs to be three virus particles transmitted by the cowpea aphid for the disease to manifest itself. Aphids can transmit all three at one time and the crop is particularly vulnerable in the early growth stages. Before 2007, farmers hardly used insecticides but a very severe outbreak of rosette in Niger in 2007-2008 that resulted in crop failures, changed things. In fact, thereafter they started in an attempt to prevent future crop failures and they now spray 1-2 times early in the crop development, trying to kill the aphids that transmit the virus. The degree of virus prevention is not very high in years of high aphid numbers.

Peanut clump virus (PCV)

PCV is thought to be transmitted by a fungus to graminaceous hosts, and then to groundnut. The infectivity of soil was related to the presence of the fungus *Polymyxa graminis* which is a parasite of plant roots. *P. graminis*

is non-pathogenic, but has the ability to acquire and transmit a range of plant viruses such as PCV, which results in significant yield reduction. Seed transmission is known only in groundnut. Seeds collected from the diseased plants produced 20% of diseased seedlings. Great millet *Sorghum arundinaceum* is a symptomless natural host.

Groundnut			
Disease	Damage	Available Control Measures	Pesticides
Damping off fungi (Fonte des semis)	Causes death and wilting of the young plants. Surviving plants may have reduced growth and yellowing leaves. A fine white powdery can be seen at the soil surface. Seedling tissues appear to be water soaked at the ground level.	-Crop rotationAvoid wet soilsPlanting on ridges to allow drainageAmending the soil with compost to create air spaces in the soilFavor good drainage and good soil aerationUse treated seedsWater only when soil is dry Apply a thin layer of straw to absorb the moisture.	Fluopicolide or fosetyl-aluminum. Seed treatment: thiram. Application of Neem Cake at 100 kg/ha. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
Leaf spot fungi (Cercosporiose)	Defoliation and reduced yield at Harvest. Chlorotic flecks on leaf petioles, stems and pegs that enlarge and turn dark in color; lesions on upper surface of leaves with a yellow halo and are reddish brown on the underside of leaves.	-Tolerant varietiesDestroy crop residueIf disease is endemic, a rotation away from groundnut for a period of 2-3 years.	Sulfur fungicide. Application of Neem oil at 3 ml/liter immediately after noticing the spots. Also could act as a preventive measure and restrict the spread of the spores through forming a thin oil cover on the leaf.
Bacterial wilt (Flétrissement bactérien)	Discolored and rotten roots and pods. First, slight drooping or curling of leaves. Then, the plants may bend over at the tip, appear dry, and eventually turn brown, wither, and die. Dark brown discoloration in the xylem and pith, and the streaming of bacterial ooze.	-IntercroppingCrop rotationResistant variety.	No pesticides are very effective. Garlic extract: 5 kilo garlic and grind to make a paste and roll the paste in a cloth. Soak this garlic paste in kerosene overnight and press the cloth to extract the liquid. Make up this extract in 100 litres of water in order to spray it on one acre.
Groundnut rust (Rouille des arachides)	Orange pustules appear on undersides of leaves which become covered in masses of	-IntercroppingCrop rotationResistant variety.	Mancozeb if the disease is spreading

	red-brown spores. Small and shrieveled seeds.	-Synchronous plantingAllow field to fallow for at least one month between successive groundnut plantingsRemove any volunteer groundnut plants during fallowing to reduce inoculumcollection and destruction of plant debries.	(spray at 3 to 4 grams/liter). Neem oil is also recommended.
Rosette virus	Leaf chlorosis/stunting, stunting without chlorosis, leaf mosaic.	-Resistant varietyDense plantingIntercropping Roguing out and disposing of infected plants away from the fieldInstallation of yellow plates in the field smeared with grease could attract aphids.	Neem seed extract. Chili extact. Soap. Control the aphid vector: spray 10 days after crop emergence and the presence of aphids, second spray after 10 days. Maximum of 4 applications, if infestation is high.
Peanut clump virus (PCV) Pecluvirus	Severe stunting reduced pod setting in the common strain. Mottle and chlorotic ring spots appear on new tip leaves then disappear when the leaves mature. The plant stops growing. A yellowing strain causes concentric yellow linepatterns in old leaves but no stunting. Mottle and chlorotic ring spots appear on new tip leaves and persist, the yellow color becoming more prominent.	-Resistant/tolerant varietyPathogen free seed Immediately after identifying the symptom at one corner, pluck the plant and burn it.	Pesticides do not control the disease pathogen, but milk spray at 5% could be tried.

Nematodes

Root knot nematodes Meloidogyne, Rotylenchulus, Belonolaimus

Root knot nematodes feed within newly developed roots and they cause characteristic galls up to 3 cm in diameter. Galls can appear on groundnut roots as quickly as a month after planting, and they interfere with the flow of water and nutrients to the plant. It is important not to mix up galls caused by nematodes with nodules caused by beneficial nitrogen fixing bacteria: nodules are pink inside when split apart and damage areas usually appear as irregular patches in the field and are frequently associated with lighter-textured soils. Infected plants are prone to wilt in hot weather, and respond poorly to fertilizer. Nematode attack in the

seedling stage leads to pre- and post-emergence damage resulting in reduced crop stand. Nematode mature females resemble tiny, white pearls; they sometimes can be seen with the use of a hand lens when root galls are cut open. Damaged roots have a greatly reduced ability to take up water and nutrients from the soil, and this leads to expression of aboveground symptoms and yield reductions. With moderate initial population densities of sting nematodes, young plants may experience reduced vigor, slow growth, and stunting.

Check roots of plants mid-season or sooner if symptoms indicate nematodes. If nematodes are known to be present in the field, preventative measures can be taken (see table below).

Groundnut			
Nematode	Damage	Available Control Measures	Pesticides
Root knot	Plants wilt and	-Weed management.	Spirotetramat
nematode	appearance of root	-Use plant resistant/tolerant varieties.	(spray into
(Nématode à	galls/knots of different	-Crop rotation/plant trap-plant like	roots, especially
galles) and	sizes and infected	groundnut before crop.	effective when
sting	roots also become	-Mix cropping or cover cropping with non-	plants are
nematode	enlarged and	host crops.	small).
	distorted. Stunted	-Field solarization (heat treatment).	
	plant growth and	-Flood the plot.	Application of
	yellowing of leaves.	-Use manure in nursery.	neem cake to
	Cropped-off roots just	- Increase the organic matter of the soil.	the soil.
	below the soil surface	-Avoid to grow on an infected plot.	
	and sometimes	-Dig up and let drying attacked plant.s	
	complete destruction	- Deep plowing during the summer to	
	of them. Reduced	expose nematodes to heat.	
	vigor.	-Sowing marigold where the root exudates	
		of marigold have some control on	
		nematodes.	

COWPEA

Cowpea *Vigna unguiculata* originated in the savannah region of West and Central Africa, where it is the most important food legume. This region represents over 66% of the 12.5 million ha grown worldwide. Cowpea is a warm season legume mainly grown in the semi arid tropics by subsistence farmers, and is a recommended food crop for the reduction of malnutrition in weaned infants among many poor communities in the world. It is one of the most economically important indigenous African grain legumes and a major crop in regional trade within West and Central Africa. The relatively high protein content of cowpea (22%) makes it an essential supplement to the diet of many Africans who consume high carbohydrate but low in protein cereals, root and tuber crops. Cowpeas are cultivated for the seeds (shelled green or dried), the pods or leaves that are consumed as green vegetables or for pasture, hay, silage and green manure.

Although achievements made by breeding new cowpea varieties suitable for intercrop and sole crop and drought conditions, average yields in farmers' fields in the Sahel remain very low (0.2–0.5 ton/ha) due to numerous biotic and abiotic constraints. Cowpea roots have *Rhizobium* root nodules that are able to fix nitrogen even in very poor soils (organic matter less than 0.2%, sand content > 85%). Cowpea is shade-tolerant and therefore compatible as an intercrop with a number of crops. All these qualities have contributed to the widespread distribution of cowpea in the semi-arid regions of West Africa, where other food legumes do not perform well. Even though cowpea is self-pollinating the flowers provide sustenance for pollinators and beneficial arthropods such as parasites and predators. They can be conserved by using selective insecticides and spraying in the late afternoon.

Insect pests

Hairy caterpillar *Amsacta moorei*

Hairy caterpillar is a large fast moving caterpillar covered with long black bristles. The head and tail regions are black but the midsection is orange brown. Minute pellets of larval excreta and/or early instars feeding gregariously in large numbers on the undersides of leaves are also visible. Crop losses caused by the caterpillar during different years vary from minor damage to complete crop failure as bands of marching caterpillars occurs in the endemic areas but no attempt has so far been made to estimate losses caused by this species to different crops. The hairy caterpillar pupates deep in the soil and passes the dry season in dormancy and resumes development with the rains. Outbreaks, and hence heavy crop losses, are likely to occur in years of substantial and frequent or intermittent rains during the first 25-30 days after start of moth emergence.

Scout weekly fields from the first sowing week, looking for defoliation patches done by the caterpillars. Spot insecticides only around the patches of damage.

Cowpea aphid Aphis craccivora

The cowpea aphid is primarily a pest of cowpea seedlings but often invades flowers and pods. Congregating on lower leaf surfaces and on terminal buds, adult and nymphal stage aphids extract plant sap with their needle-like mouthparts. Then honeydew and mold further reduces photosynthesis. It not only causes direct damage to the cowpea plant but also acts as a vector in transmitting of Cowpea aphid-borne mosaic virus and other viruses. Wingless female adults, known as "stem mothers," give birth to about 80 nymphs over a 2-1/2 week period. They also disperse in the air but as there are many host plants year round, they do not seasonally migrate north from Nigeria. In the dry season (winter) in the tropics, the aphid survives on wild leguminous weeds/hosts. It disperses when rains start and colonizes cowpea 3 weeks after crop emergence but the main migratory flight occurs 2-3 weeks later. The aphid reproduces faster and is less susceptible to insecticides than its natural enemies. Most plants can tolerate moderate numbers of aphids without great damage. However, even small numbers may need to be controlled in cases where aphids transmit virus diseases.

Early and regular monitoring of aphid population and of their natural enemies is imporant. To monitor aphid populations, examine the undersides of the leaves and the bud areas for groups or colonies of aphids. Another method is to use yellow pan traps. Three weeks after crop emergence, sample 20 randomly selected plants each week. Apply insecticide if more than 20% of the plants are infested and at least 1 in 10 plants is heavily infested. Neem seed extract is effective. For cotton aphid (*A. gossypii*), a corrective action is recommended if 30% of the plants are infested during the first 2 months of the season.

Another option, instead of using threshold levels, is to monitor growth of the aphid population within 3 to 5 days. If a rapid growth of the number of aphids per plant is observed, and no or only few predators are present, treatments should be planned. Notice that prompt control is necessary when numbers build-up and natural control is not satisfactory.

African bean flower thrips Megalurothrips sjostedti

Thrips are tiny, black slender insects with fringed wings. They migrate long distances in the wind and seasonally move northwards from Nigeria with the rains. They feed by puncturing plant tissue and sucking out the cell contents. During the pre-flowering period, nymphs and adults may damage the terminal buds. However, the main damage is on the flower buds and flowers. Thrips can cause yield losses of up to 100% and is a more serious pest than other species such as *Frankliniella* and *Sericothrips*.

Monitor Adult thrips by yellow sticky traps in the field regularly and conduct early detection. Only a few are needed in a community to determine when infestations are beginning. Three weeks after crop emergence sample 20 randomly selected plants each week. Shake leaves and flowers onto a white piece of paper. Foliar

treatment is recommended when 25% of the leaves or 20% of flowers show thrips damage and pest populations are still active.

Whitefly Bemesia tabaci

Whiteflies are tiny, sap-sucking insects that are frequently abundant in vegetable and ornamental plantings. They derive their name from the mealy white wax covering the adult's wings and body. They occur in groups on the undersides of leaves. Outbreaks often occur when the natural biological control is disrupted. One can see them fly off when the foliage is disturbed. Fortunately no virus diseases are transmitted by whiteflies on cowpea.

Three weeks after crop emergence, sample 20 randomly selected plants each week. Use yellow sticky traps, as well as mass trapping with six traps per hectare. Apply a selective insecticide when 50% of plants have whiteflies and the infestation is increasing.

Blister beetles Mylabris spp.

The adults are medium to large sized beetles (2-5 cm in length), usually black and yellow or black and red. The larval immature stages live in the soil and are beneficial as predators of grasshopper eggs. The adults feed on bean flowers and on pollen from a wide range of plant families thus intercropping favors them. Adults can be a problem when present in large numbers. They are highly mobile and seek out cowpeas in flower to feed, resulting in lower yield and serious damage. Note that it is difficult to control this pest with insecticide sprays as the beetles feed on flowers that persist only for a day and are highly migratory.

Pod borer Maruca vitrata

Maruca is a pest of many grain legumes, and the most important pod borer pest, causing severe damage to cowpeas. Losses over 80% have been reported on indigenous varieties and even on high yielding varieties. Eggs of this small moth are laid on flower buds. Larvae are dull to yellow-white and up to 1.8 cm length. Each segment has dark spots that form a distinct series along the length of the body and the head is dark brown to black. Larvae secrete silk webbing around feeding sites on flowers that protects them from natural enemies and also shields it from insecticides. One larva occurs per flower and feeds on tender parts of the stem, peduncles, flower buds, flowers, pods, and developing seeds in pods. Once a flower is consumed, the larva uses silk threads to form bridges to move to other flowers nearby. One larva may consume 4-5 flowers before pupation. The larger third to fifth stage larvae tunnel into green pods to feed on the seeds. There is no dormancy; Maruca survives the dry season further south in the wet zones and moves northward from Nigeria with cowpea plantings in the rainy season.

Beginning at flowering, sample 20 randomly selected plants each week and treat if there are as much as or more than 3 larvae/20 plants.

Seed feeding bugs Anoplocnemis curvipes, Clavigralla tomensicollis

These large bugs suck the sap from green pods. From cage studies *Anoplocnemis* was observed to be the more damaging coreoid species per insect causing a yield reduction of 40%, followed by *Clavigralla* (20%). The fourth stage nymph of each pod-sucking bug species caused significantly higher cowpea yield reduction than adults. Similarly, infestation on young pods compared to mid-fill and mature stages resulted in significantly higher yield reduction.

Beginning at podding, sample 20 randomly selected plants each week. Treat when there are 2 *Anoplocnemis* bugs per plant or 4 *Clavigralla* bugs.

Cowpea			
Insect Pests	Damage	Available Control Measures	Pesticides
Hairy caterpillar	Defoliates young plants	-Destroy marching bands of	If caterpillars are
	usually before flowering,	caterpillars by digging trenches	small, use neem
	leaving only the main	around the fields and burying them.	seed extract or

	veins. Can kill young plants.	-Collection and destruction of egg masses and young larvae in the gregarious phase of the pest Community burn fires in the evening from 6 to 9 pm to attract the adult moth where the moths fall in fire and die Light traps.	chili extract. If not, use spinosad.
Cowpea aphid (Puceron du niébé)	Aphids attack terminal leaves, flower heads, petioles and stems of pods. Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Heavy feeding kills seedlings while causing stunting, leaf distortion, delay of flowering, and reduced fruit set.	-IntercroppingResistant variety (but might not work locally)Provide good plant nutrition to increase toleranceEarly plantingRemove dry season alternative hostsSow in close spacingIPM based on plant resistance plus intercropping and selective insecticides.	Horticultural oil, neem seed extract, chili extact, or soap. Lambda cyhalothrin, deltamethrin, or dimethoate. Application of Neem oil is highly recommended and is highly effective for aphids. Note that resurgence occurs from synthetic pyrethroids that kill more natural enemies than aphids. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: lambda cyhalothrin, deltamethrin, and dimethoate.
African bean flower thrips (Thrips des fleurs)	Feeds on the flowers which inhibits fertilization and pod formation. Damaged flower and flower buds. Attacked flower buds become	-Intercropping with tall cereals.-Mixed cropping habitat.-Early planting.-Fertility management.	Horticultural oil, spirotetramat, laundry bar soap, neem seed extract, spinosad,

	brown, distorted, malformed and eventually fall off, leaving behind dark red scars. Malformation of pods.	-Installation of white sticky traps (thrips are more attracted towards white florescent color).	imidacloprid, or acetamiprid. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: Lambda cyhalothrin.
Whitefly (Mouche blanche)	Attacked leaves dry out, become yellow, roll up and fall, plants growth stops. Sticky leaves and covered with black sooty mold.	-IntercroppingPut insect-proof nets to protect the nurseryYellow sticky traps reduce populationsWater regularly the foliageAfter the last harvest, destroy all crop residuesRepellent plant like Arican marigold could be planted randomly in the field.	Spray neem seed extract, laundry bar soap, or Horticultural oil. If greater control is warranted spray spinosad, pymetrozine, or imidacloprid.
Blister beetles (Coléoptères)	The adults feed on bean flowers (petals, pollen), reducing pod set.	-Collect with nets and feed to chickens (don't touch them: they have a defensive chemical)Tolerant variety.	Neem seed extract.
Pod borer (Foreur de la gousse)	Eggs laid on flowers, larvae damage flowers, enter green pods to feed on developing seeds. Silk webbing around feeding sites on flowers.	-Plant earlyPrefer cultivars where the foliage is not near the pods held within the canopy.	Neem seed extract. Tebufenozide, lambda cyhalothrin, deltamethrin, or dimethoate. Chilli-garli extract. Take 3 kg green chillies and grind to take extract. Take half kilo garlic and make a paste out of it after grinding, soak overnight in kerosene and take extract. After filiter these extracts by adding 70 grams of detergent and

			dilute in 100 liter of water befor spraying on one acre.
Seed feeding	Feed on seeds in fresh	-Resistant variety.	Neem seed
bugs	cowpea pods and	-Intercropping with wider spacing.	extract.
(Insectes se	introduce secondary	-Plant early.	
nourrissant de	pathogens which destroy	-Clean up debris from previous crops.	
la graine)	seeds. Dried and		
	shriveled seeds.		

Stored product

Bruchid weevil Callosobruchus maculates

Bruchids infest beans in the field at harvest time and are taken into storage inside the seeds, being the principal storage pest of cowpea. They may infest up to 100% of the stored seeds within 3 to 6 months under ordinary storage conditions. Crops destined for human consumption, export or for seed can be rejected due to feeding from this pest. Adults are 2.0-3.5 mm long and feed on pollen in the field. Eggs are laid singly on the pods or seeds. A female adult can lay over a hundred eggs, and most of them will hatch. She lays an egg on the surface of a bean, and when the larva emerges about 4 to 8 days later, it burrows into the bean. During development, the larva feeds on the interior of the bean, eating the tissue just under the surface, leaving a very thin layer through which it will exit when it matures. It emerges after a larval period of 3 to 7 weeks, depending on conditions.

Before storage, dry seeds to moisture content below 13%. The triple plastic bagging method of cowpea seed storage uses three 50 kg size plastic bags: place them inside one another, fill the first bag and shake and press down to remove the air, twist the plastic of the open bag to make it tightly closed and tie it with a string, repeat for the other two bags. If most of the air has been removed, the weevils will soon die of dehydration.

Cowpea			
Damage	Available Control Measures	Pesticides	
Infestation starts in the field. Weevil larvae develop within grains to render them unfit as seed or food. Leave holes in the seeds.	-Control cowpea pests infesting pods in the fieldPlant resistance/multiple pest resistant to bruchids, aphids, and thripsTight sealing vesselsAshSun dry for three daysTriple bag with plastic bags where the air is pressed outBags not to be opened until all product is to be usedFor smaller amounts (such as for seed) can use hermetically sealed recycled plastic containers, such as "bidons".	Neem seed extract to cowpea seed before storage in a tight container or triple plastic bag method. Add neem leaves to the seed. Containers could also be	
		treated with	
	Infestation starts in the field. Weevil larvae develop within grains to render them unfit as seed or food. Leave holes in the	Infestation starts in the field. Weevil larvae develop within grains to render them unfit as seed or food. Leave holes in the seeds. Infestation starts -Control cowpea pests infesting pods in the fieldPlant resistance/multiple pest resistant to bruchids, aphids, and thripsTight sealing vesselsAshSun dry for three daysTriple bag with plastic bags where the air is pressed outBags not to be opened until all product is to be usedFor smaller amounts (such as for seed) can use hermetically sealed recycled plastic containers,	

	neem extract before storing.

Diseases

Damping off fungi Rhizoctonia sp., Phythium sp., Fusarium sp.

Please see millet/sorghum.

Cowpea bacterial blight Xanthomonas campestris pv. vignicola

The pathogen is reported from all areas of the world where cowpea is cultivated. It is both internally and externally seed borne. It may cause severe defoliation during periods of high humidity. Warm and wet conditions favor plant infection by the bacterium. Free moisture is required for host invasion, considering that the natural route of infection is through pores in the leaves called hydathodes. The optimum temperature range for bacterial growth and host symptom development is between 25° to 30°C. A slower rate of growth is observed at temperatures up to 35°C.

Use sodium hypochlorite (Clorox 5.25%) for each 10 gm of seed mix 1 tablespoon (18 ml) product with 100 ml of water to obtain a solution with 10,000 ppm available chlorine. Put seed in a cheesecloth bag, submerge in this solution and provide continuous agitation for 40 minutes, rinse seed under running tap water for 5 minutes, then dry seed thoroughly on a paper towel, hydrogen peroxide (place seeds in porous nylon mesh bags, soak for 4 hour soak in 3% dilution or 40 minutes in 30% solution, rinse three times then air dry seeds).

Cowpea aphid-borne mosaic viruses (CabMv)

Mosaic diseases found on cowpea include: 1) cowpea mosaic comovirus (CpMV), 2) blackeye cowpea mosaic potyvirus (BICMV), 3) cowpea severe mosaic virus (CPSMV), 4) cowpea aphid-borne mosaic potyvirus (CAMV) 5) cowpea mottle carmovirus (CPMoV), 6) cowpea golden mosaic begomovirus. These viruses are seed borne and then mainly transmitted by *Aphis craccivora* in a non-persistent manner and by infected cowpea seeds. Other aphid species that *Aphis craccivora* can transmit the viruses: *Myzus persicae*, *A. citricola*, *A. gossypii*. *Toxoptera citricidus*. Yield losses generally between 30-40% but can reach 97-100%. Vein clearing symptoms appeared on the new cowpea leaves 2 to 4 weeks post-inoculation access feeding period. Green vein banding, mosaic, and leaf curling symptoms were also observed on the further developmental stage of infected cowpea seedlings. Note that insecticides directed at controlling the aphids can interfere with plant to plant transmission.

Charcoal rot Macrophomina phaseolina

Charcoal rot, which affects the water balance and plant turgor of cowpea, is one of the most important constraints to higher production, causing an average yield loss of 10%. Plant parts at all stages are susceptible to infection. It produces sclerotia that enable it to survive adverse environmental conditions. In the absence of hosts, the fungus survives in soil and host tissues in the form of microsclerotia, which are able to survive for 2–15 years depending on environmental conditions. Charcoal rot is a soil borne plant pathogen with a very wide host range. High root infection can occur before reproductive development and is then associated with hot and dry weather early in the growing season. Once the hypocotyl is girdled, the seedling will die. Infection can spread into the taproot and stem. Once the stem is girdled, the plant will wilt and the fungus rapidly colonizes the remaining tissues. The dead tissues turn black as microsclerotia are abundantly produced.

Pod rot Choanephora cucurbitarum

Choanephora fungus attacks the withering floral parts of many plants after fertilization, and invades cowpea pods. Infected pods bore the luxuriant whitish growth of the fungus on the exterior which produced black headed pinpoint sporangia around the pods. Developed pods shrink around the bulging seeds inside. The fungus is transmitted by mechanical damage to pods that comes from insect, usually weevil, feeding or

oviposition sites on pods. In fact, a wound is needed for *Choanephora* to infect a pod. However, the fungus is air-dispersed so the question of whether the weevil is a vector or merely opens a wound rapidly from pod to pod in containers after harvest. Incidence in northern Nigeria was 7 and 20% in two surveyed areas. Losses are especially high during very rainy wet seasons.

Cowpea			
Disease	Damage	Available Control Measures	Pesticides
Damping off fungi	Soil borne pathogens attack seedlings causing	-Clean seed. -Plant on ridges.	Fluopicolide or fosetyl-aluminum.
(Fonte des semis)	them to wilt and die	-Wide spacingAvoid water stress by planting early.	Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
			Seed treatment: mancozeb or thiram.
Cowpea bacterial blight (Brûlure bacterienne du niébé) Xanthomonas axonopodis pv vignicola	Symptoms begin a dark spots on leaves, pods, and stems; which then enlarge into irregular foliar lesions with yellow margins, premature leaf fall, stunting and wilting. Water soaked areas can be seen on pods	-Intercropping3/4 years crop rotation with non-host plantDisease free seedTolerant varietyRemove alternate/cruciferous weed hostsControl insects that make woundsRemove crop debris after harvestSanitation (such as clean equipment, avoiding work in wet fields).	Biopesticides: Pseudomonas fluorescens or Bacillus subtillis applied prior to or in the early stages of disease development. Application of dried ginger and milk solution. (Take 200 grams of dried ginger mixed with 5 liters of milk. Eventually dilute in 2 liters of water. Make up to 100 liter to spray at one time).
Cowpea aphid borne mosaic virus (CabMv) (Virus de la Mosaïque porté par le puceron du Niébé)	Mosaic, vein clearing, green vein banding, stunting, curling, and distortion of the leaves randomly in the field	-Rogue infected plantsPathogen free seedControl the aphidResistant varieties where availableRemove alternative hosts of virus diseases (legumes)Intercropping with cerealsUse compost Create a community wide host free period for two months during the dry season.	See controls of cowpea aphid.
Charcoal rot (Pourriture charbonneuse)	Wilting and death of the plant, seedling blight, root and stem rot symptoms. Sclerotia (spore storage	-Compost and organic soil amendmentsThorough tillageTolerant varieties.	Fungicide usage is uneconomical.

	organs) in root and stm tssues. Stem and root lesions first appear water- soaked then turn a dull light brown.	-Crop rotation with cereal.	
Pod rot (Pourriture brune)	Water soaked, dark green lesions on the pods subsequently becoming a wet rot that affected young and old pods	-IntercroppingInsecticide control of flower and pod pests.	Fungicide usage is uneconomical.

Weeds

Striga Striga gesnerioides, Alectra vogelii

As with the Striga that attacks cereals, the species that parasitizes cowpea causes severe damage in the Sudano-Sahelian belt. The *Striga* infection in cowpea is more devastating in areas with sandy soils, low fertility, and low rainfall. A second parasitic weed *Alectra vogelii* also occurs on cowpea but in wetter areas. In many areas, both parasitic weeds occur. Striga is difficult to control because it produces large numbers of seed and up to 75% of the crop damage is done before the Striga plants emerge from the ground. Note that control strategies based on the use of herbicides are too expensive for low-input farming systems, while cultural practices offer mainly long-term benefits.

Cowpea				
Weed Pests	Damage	Available Control Measures	Pesticides	
Striga	Parasitism causes severe chlorosis, wilting, and stunting resulting in yield losses	-Intercropping.-Crop rotation with a cereal (such as millet and sorghum).-Resistant variety.	Herbicide control is uneconomical.	

OKRA

Okra, also called lady's fingers, originated in Ethiopia but is also well known in Niger and extremely popular in African cookery. It is mainly grown for its young immature pods, which are consumed as a vegetable, raw, cooked or fried, and need no special preparations besides washing, topping, tailing and cutting up. The pods can be conserved by drying or pickling. The leaves are sometimes used as spinach or cattle feed, the fibres from the stem for cord, the plant mucilage (thick gluey substance) for medical and industrial purposes, and the seeds, that contain good quality oil and protein, as a substitute for coffee. The region's soil is low in organic matter and land degradation is a crucial challenge to be addressed. With the rapid urbanization and population growth, market-oriented okra production is increasing in peri-urban zones. Okra is now cultivated as an irrigated crop during the dry season, where it is often produced in mixed cropping with onion and other crops. On degraded land, okra has proved to be an important rainfed crop. In between the demilunes women plant high value traditional vegetables such as specially selected varieties of okra in 20x20 cm deep planting pits which catch run off rainwater. Although okra is considered a robust crop, under large-scale commercial production, yield losses are very high due to the incidence of a number of pest and abiotic stresses.

Insect pests

Flea beetles Podagrica spp.

Flea beetles are tiny to small beetles, with enlarged hind legs that enable them to jump long distances when disturbed. Adult's color varies from black, brown, black and yellow striped or metallic blue-green, depending on the species. Adults feed at night on seedlings right after germination. Larvae live in the soil and feed on okra roots, but the damage caused is not of economic importance. Flea beetles are particularly damaging to young plants. Seedlings may wilt and die under heavy flea beetle attack or may stunt, if injury is not severe. Damage to cotyledons and young leaves is the major cause of crop loss, generally leading to uneven crop stand. When large numbers of flea beetles are present they will also feed on flower buds and pods, causing yield loss by injuring the pods and making them not marketable. Furthermore, flea beetles are reported to transmit the okra mosaic virus in West Africa.

One week after crop emergence, sample the field to note feeding damage by flea beetles. If the damage occurs on more than 25% of the seedlings, treat with approved pesticides at insect appearance during first crop stages.

Whitefly Bemisia tabaci

Adults are winged, they are 1.0-1.5 mm long and their yellowish bodies are slightly dusted with white waxy powder. They have two pairs of pure white wings and prominent long hindwings. Adults and nymphs of the tobacco Whitefly suck sap from leaves of okra plants. Damage may also be accentuated when plants suffer water stress. Whiteflies excrete honeydew on which sooty mould growth. In addition, it damages the leaves when it removes the sap by producing a number of chlorotic spots as a result of removing the contents of cells in the epidermis. Heavy infestations are often caused by insecticides directed at other insect pests but that kill the whiteflies' natural enemies.

Before fruit development, monitor 20 plants weekly. Routinely check field margins for whiteflies: these areas are usually infested first. If 40% of leaves average at least 3 adults, use approved pesticides.

Cotton aphid Aphis gossypii

The different forms of the cotton aphid differ in their ability to cause population outbreaks and plant damage, therefore it is important to be aware not only of the number of aphids present, but also of their color form. The small yellow aphids develop slowly from newborn nymph to adult and do not produce many offspring; thus, their populations rarely increase rapidly. On the contrary, the larger, darker aphids (green and black) develop more rapidly, produce many more offspring in a rapid burst, and can generate rapid population growth rates. This green aphid is rarely conspicuous when young, unless the plants are heavily infested. Okra appears to be able to compensate fully for early season damage as long as the aphid feeding ceases but, if damage occurs at the flowering and fruit development stage the number and size of fruits are affected.

Treat for aphids if high populations persist for 7 or more days. The treatment threshold is 25% of infested seedlings, 50 aphids per plant at later growth stages.

Leafhopper Empoasca lybica

Empoasca lybica's eggs are laid in midribs, which become roughened. Pale green adults and nymphs suck sap from veins on the undersides of mature leaves, mostly on the lower half of the plant. While feeding, they inject a toxin that causes a disease like symptom called hopper burn or yellowing along leaf edges. Nymphs are easily detected as they move side to side while adults fly away when disturbed.

If large numbers migrate to cotton from other hosts and extensive symptoms appear, treatment may be needed when first damage appears, particularly at seedling stage. No treatment is necessary after fruiting.

Spotted bollworm Earias vittella, spiny bollworm Earias insulana

The full grown dull-green caterpillars are 2 cm long, have tiny stout bristles and a series of longitudinal black spots on the body. The incidence of fruit borers usually occurs during humid conditions after the rainfall. The adult female lays eggs individually on leaves, floral buds and on tender fruits. The larvae bore into the top

tender shoots and tunnel downwards the main axis that wither, droop down, and growing points are killed. Later on they bore into the fruits and feed within. When pod production starts, the caterpillars move to the flower buds, small pods, and eventually, mature pods, leading to yield reduction. Furthermore, damaged and contaminated with insect excreta pods are not marketable and affected fruits become unfit for consumption.

Monitor 20 plants weekly after flowering. If damage is noted to 5% of plants, apply an approved pesticide. Target small caterpillars before they bore into the pods.

African bollworm Helicoverpa armigera

The African bollworm feeds on leaves, flowers and pods of okra. The caterpillar usually bores clean, circular holes in pods, causing extensive damage and promoting decay from secondary infection by diseases. Moist excreta usually accumulates around the base of the pod. Eggs have a disc form and newly hatched larvae have several rows of dark tubercles along the back, each bearing one or two bristles. Larvae reach 35-45 mm long and range from olive green to dark reddish brown in color and can be best distinguished from dark broken grey lines along the sides of the body. Mature larvae are the most destructive since they damage more and larger fruit that are harder for the plant to replace. The impact of a bollworm infestation depends on the number of larvae present, the age of the larvae, and the timing of damage relative to the crop's fruiting cycle. The African bollworm has many natural enemies that are important for its natural control: parasitic wasps, predators such as ants, lacewings, and ladybird beetles.

Monitoring and control for recording densities of small larvae since although large larvae do most of the damage, it is not possible to kill a significant proportion of them once they are older than the third stage. Begin weekly sampling at flowering. For standard sampling, check for larvae on the terminal growth of 20 plants chosen at random. Good spray coverage and targeting small caterpillars before they bore into the pods is very important.

Blister beetle Mylabris

Flower beetles adult, also known as pollen or blister beetles, is colorful and about 2.0-2.5 cm in length with red or reddish orange and black alternating bands on the forewing. Eggs are laid in the soil. Upon hatching, young larvae are very active and mobile searching for eggs of grasshoppers and locusts. The larvae then burrow underground and start feeding on the eggs. Older larvae become sluggish and change shape turning fat, getting a large body and reduced legs. These beetles are difficult to control because of their mobility. The damage caused is usually not of economic importance.

Leaf miner *Liriomyza trifolii*

Please see the tomato section for general information on this pest.

Cotton stainers/seedbugs Dysdercus spp., Oxycarenus sp.

Cotton stainers *Dysdercus* spp. are between 14 and 24 mm long, red colored with black bands. Both adults and nymphs feed on developing pods and seeds, piercing them to suck sap. Stainers also attack cotton and they live on baobab and kapok trees. They attack okra from the early stages of the crop, but are more common during the mature stages. Attacked young fruits shrivel and then dry where as attacked mature fruits result in damage to the seeds.

Cotton seed bugs *Oxycarenus* sp. are small (4 to 6 mm), blackish with transparent wings. They attack open or damaged pods mainly at the end of the growing season. Nymphs and adults suck from immature seeds, preventing them from ripening. Groups of bugs are usually found between flower buds, flowers and pods. These bugs are minor pests of okra and usually no control measures are needed.

Monitor 20 plants beginning at flowering. If 10% of the plants have seed feeding bugs, apply approved pesticide.

Spider mites Tetranychus spp.

Spider mites adults are minute in size (about 0.6 mm long) and vary in color (green, greenish yellow, brown, or orange red) with two dark spots on the body. They feed on the lower surface of leaves. Mites produce a large amount of webbing which, in heavy infestations, may cover the leaves. Plants may die when infestation is severe, particularly in hot dry conditions. In severe infestation, spider mites will also attack pods, causing pod contamination. Major factors leading to spider mite outbreaks are very hot and dry conditions, destruction of natural enemies, and the presence of other infested highly infested crops in the vicinity of the okra crop.

Beginning three weeks after crop emergence, sample 20 plants weekly. When 30% of leaves show mite presence, a treatment is recommended.

Okra			
Insect Pests	Damage	Available Control Measures	Pesticides
Flea beetle (Altise)	Lots of little holes (known as 'shot-holes' in the leaves of a young crop as well as on cotyledons and stems. Attacks flowers, green pods, and fruits, leading to rotting. Larvae feed from roots. Eggs are laid near attacked plants in the soil.	-Observe plants as early as possible to identify first fleasAvoid to grow near malvaceae, such as sorrel bissap or cotton plantDuring the dry season, plough the soil 30 to 40 cm deep to expose larvaeWeeding.	Neem seed extract.
Whitefly (Mouche blanche)	Attacked leaves dry out, roll up, plants growth stops, and a black wax can be found on attacked organs. Low vigor and wilting, yellowing, and eventually dying of plants. Honeydew on leaves that then turn black, eventually dry and fall off. Wilting and shedding of leaves and fruiting branches when heavy infestations.	-IntercroppingPut insect-proof nets to protect the nurseryYellow sticky traps reduce populationsWater regularly the foliageAfter the last harvest, destroy all crop residues.	Spray neem seed extract, laundry bar soap, or horticultural oil. If greater control is warranted, spray spinosad, pymetrozine, or imidacloprid. Vtex extract.
Cotton aphid (Puceron du coton)	Suck sap under leaves, stems and young buds. Leaves become yellow, distorted and dry. Presence of black wax on attacked organs. Shiny and wet leaves due to honeydew. Severe stunting of seedling growth.	-Put insect-proof nets to protect the nurseryWater regularly the foliageGood plant fertilizationLess suceptible varieties.	Horticultural oil, neem seed extract, chili extact, or soap.

Leafhopper (Cicadelle)	The injured leaf margins turn yellow then brown and tend to curve downward. Leaves become distorted, leathery, develop yellow or red blotches and eventually dry out and fall down. Severe infestation may cause plants to shed squares and small bolls. Larger bolls may turn soft and spongy, and fail to mature. Other species cause leaf stippling. Larvae bore into shoot	-IntercroppingObserve plants at crop beginning to identify symptoms as soon as possiblePlant resistant variety (such as hairy varieties)Balanced plant nutritionAvoid to grow near malvaceae or solanaceaeConserve natural enemies.	Flonicamid, laundry bar soap, or neem seed extract.
Spotted bollworm (Ver de la capsule tacheté) Spiny bollworm (Ver de la capsule épineux)	terminals and eventually the fruit. Kill growing points.	-Use of asnRemove damaged shoots and fruitsNutrient managementDestroy crop residue and old crops after harvestUse only judicious levels of nitrogen fertilizers, as they increase spiny bollworm infestation.	Tebufenozide, Bacillus thuringiensis, or neem seed extract.
African bollworm (Ver de la capsule africain)	Young larvae feed on tender foliage, advanced stage/s attack the pods and one larva may destroy many pods. Main damage occurs on flowers, causing flower abortion, and pods.	-IntercroppingPlanting a trap crop of pigeon pea along the field borderHandpick and destroy eggs and caterpillars (particularly helpful when numbers are low and in small fields)Conserve natural enemies by using selective insecticides.	If young larvae, then use Bacillus thuringiensis or neem seed extract. If older larvae, use chloranthraniliprole, methoxyfenozide, indoxacarb, or tebufenozide.
Blister beetle	It feeds on flowers, reducing pod set, as well as on foliage, biting off irregular patches on leaves.	-Collect with nets and feed to chickens (don't touch them: they produce a defensive chemical)Tolerant varietyPlant a trap crop of flowering plants around the field.	Neem seed extract.
Leaf miner (Mouche mineuse des feuilles)	Mines and white marks on the leaf surface.	-Install insect-proof nets to protect the nurserySpray repellent substances of garlic, onion, or red pepperPerform a shallow ploughingRemove crop residues.	
Cotton stainers/seed bugs (Insecte de la graine du coton)	Feed on okra seeds and pods. Reduction of yield and germination. Small, dark, raised blister-like spots.	-Removal of weed and malvaceous hosts near okra fieldsSanitationRemove plants and all its debris as soon as harvesting is overDestroy wild alternate hosts.	Neem seed extract or imidacloprid.

Red spider	Tanned and yellow color and	-Use crop resistany varieities.	Horticultural oil.
mites	speckled or mottled	-Weed management.	
(Araignée	appearance of leaves. Lower		
rouge)	leaf surface shows the mites		
	as tiny moving greenish or		
	reddish speckles. Heavily		
	infested leaves turn yellow,		
	curl up, dry and are shed.		

Nematodes

Root knot nematodes Meloidogyne, Rotylenchulus, Belonolaimus

Root knot nematodes *Meloidogyne* spp. enter the roots causing characteristic root knots or galls. Nematode attack in the seedling stage leads to pre- and post-emergence damage, resulting in reduced crop stand.

The reniform nematode *Rotylenchulus reniformis* is a sedentary semi-endoparasite on the roots of plants. The female penetrates the root and remains in one position at a permanent feeding site until maturity with its posterior end projecting from the root. Males and juveniles live in the soil; males are not parasites and do not feed. Under drought conditions the nematode can persist up to two years outside a host by entering a dormant state.

Sting nematode *Belonolaimus longicaudatus* are ectoparasites of plant roots, meaning that they remain in the soil and feed by inserting a long stylet or mouth spear into root tips. Then, they inject enzymes into root tissues and suck plant juices, resulting in cessation of growing of root tips. Sting nematodes cause particular damage to young plants with a developing root system.

Okra			
Nematode	Damage	Available Control Measures	Pesticides
Root knot	Plants wilt,	-Weed management.	Spirotetramat:
nematode	leaves become	-Crop rotation and intercropping.	spray into
(Nématode à	yellow and	-Plant trap-plant like groundnut before crop.	roots.
galles)	appearance of	-Mix cropping or cover cropping with non-host	
	root galls/knots	crops.	Neem cake
	of different sizes	-Field solazisation (heat treatment).	application.
	and infected	-Flood the plot.	
	roots also	-Use manure in nursery.	
	become	-Avoid growing on an infected plot.	
	enlarged and	-Dig up and let dry the attacked plants.	
	distorted.		
	Stunted plant		
	growth.		

Diseases

Okra leaf curl virus (OkLCV)

The most relevant biotic stress of okra is the leaf curl disease caused by the begomovirus, transmitted by the white fly *Bemisia tabaci*. A single whitefly was able to transmit the disease after 48 hours for both acquisition and inoculation access. The virus is not transmitted by mechanical inoculation but by grafting and it is not

transmitted by seed. The disease has been found to be more prevalent in the savannah area than in the tropical-forest region. However, leaves produced subsequently do not show symptoms.

Okra yellow vein mosaic virus (OkYVMV)

OYVMV, belonging to the genus *Begomovirus*, family Geminiviridae, is found in northern Nigeria and probably occurs in Niger. There are two virus particles implicated in the expression of disease symptoms, thus there are variable symptoms, depending on how many particles are transmitted. The whitefly *Bemisia tabac* is the insect vector. The whitefly vector reproduces to significant numbers during the summer season when it transmits the virus between okra plants.

Okra mosaic virus OkMV

Okra mosaic virus is in the genus *Tymovirus* was first found in okra in Côte d'Ivoire, followed by Nigeria. It is likely to be widespread in many West African countries. OkMV is transmitted in a non-persistent manner by the flea beetle *Podagrica decolorata*. The virus is also sap-transmissible. Yields of affected crops are greatly reduced.

Powdery mildew Erysiphe cichoracearum

The disease is characterized by grayish powdery growth on both surfaces of the leaves, particularly on the upper surface. The white coating is the fungal growth. The disease also attacks stems, flower buds and okra pods. The disease slows photosynthesis, resulting in a reduction in economic yield. The pathogen spreads via airborne conidia and survives on the infected plant debris. Spread is favored by winds and infection is favored by warm days and cool nights that cause leaf condensation. Fungal spores need free water in order to germinate and penetrate into the leaves.

Once the disease is seen to be spreading too many plants, a sulfur fungicides can be used to manage it.

Bacterial wilt Ralstonia solanacearum

Bacterial wilt is soil borne and is a serious pest for okra in the tropics. Total collapse of the plant usually occurs when temperatures reach more than 32°C. When the stem of a wilting plant is cut across, the pith has a darkened water-soaked appearance, and on squeezing the cut stem, a white, yellow or greyish, slimy exudate may appear. In later stages of the disease, decay of the pith may cause extensive hollowing of the stem.

Cercospora leaf spot Cercospora abelmoschi

The fungus survives on crop residues in the soil and is aggressive once established. Infected leaves will often roll (making fungicide coverage difficult), wilt, and abscise, under humid conditions. The leaves, stems or roots develop small, yellowish-green to brown spots. In some cases, the old leaves may also show water-soaked spots. The fruit develop small, raised rough spots or rot spots, or fruit may fail to set. If 15% of foliage is infected by the fungus, a fungicide such as mancozeb can be used.

Okra			
Disease	Damage	Available Control Measures	Pesticides
Okra Leaf Curl	Green-yellow mottling of	-Observe plants at crop beginning to	To control
Virus	leave, turn curved and	identify whiteflies.	whiteflies, see
(Virus de	irregular, blisters on	-Avoid growing okra near cotton,	section above.
l'enroulement	young leaves and ripping	tomato and tobacco plants.	
foliaire de l'Okra)	of old leaves,	-Weed management.	
(OkLCV)	plants stunted and bear	-Dig up and burn immediately plants	
	yellow or wrinkled fruits	with symptoms.	
	with dark	-Use of cucumber grown around	
	spots. Very small plants.	border of crop.	

Okra yellow vein mosaic virus (OkYVMV) (Virus de la Mosaïque jaune de la rhizomanie de l'Okra)	Plants are very small. Vein clearing, and vein chlorosis of leaves. In severe cases, the chlorosis may extend to the interveinal area and result in complete yellowing of leaves. Fruits are dwarfed, malformed, and yellow green.	- Observe plants since the beginning to identify vector insectsAvoid growing okra near cotton plantsDig up and burn immediately plants that show symptomsPlant resistant cultivars.	To control whiteflies, see section above.
Okra mosaic virus (Virus de la Mosaïque de l'Okra) (OkMV)	Vein-chlorosis, vein- banding, mosaic symptoms, and stunting. Fruits show chlorotic flecks.	-Observe plants from the beginning to identify vector insectsAvoid growing okra near cotton plantsDig up and burn immediately plants that show symptoms.	To control flea beetle, see section above.
Powdery mildew (Oïdium ou Blanc)	Affects mainly older leaves, petioles and stems. Grayish powdery growth on both surfaces of the leaves, particularly on the upper surface. Infected leaves turn yellow, curl, dry up and shed, and even scorch and fall when infection is severe.	-Selection of field far from source of inoculumsWeed management.	Sulfur.
Bacterial wilt (Flétrissement bactérien)	The disease causes rapid wilting and death of the entire plant without any yellowing or spotting of leaves.	-Remove wilted plants from the field and destroy themPractice long-term crop rotationPlant resistant varietiesAvoid using diseased transplantsEstablish plantings in non-infested soilBurn a fire over the soil for the seedbed to sterilize itCover seedlings from the hot sun and graft them onto wild eggplant, which has natural resistanceMake furrows and sowing seeds far apart.	No pesticide is effective.
Cercospora leaf spot (Cercosporiose)	Brownish spots on lower leaves, later leaves become yellow and drop. Small raised rough or rot spots on fruits.	-Use disease-free seedCrop rotationAvoidance of overhead watering.	Mancozeb.

TOMATO

Tomatoes, native to South and Central America, are the most popular vegetable in the Sudano-Sahel. During the rainy season fruit set is very poor, probably due to high night temperatures. Some varieties have a higher fruit yield at higher night temperatures because they set more flowers. Tomatoes are grown for home

consumption and are an important source of vitamins and an important cash crop for both smallholders and medium-scale commercial farmers. Tomatoes acting as taste enhancers in food are always in high demand both for fresh consumption and processing.

Tomato yields in smallholder cropping systems in the region are generally far below the potential of the crop. Averages ranging from 7-100 t/ha have been reported from Africa. There are several reasons for low yields. Among these are low quality seeds, non-availability of inputs, sub-optimum crop husbandry, and a large number of insect pests and diseases.

Insect pests/mites

Cutworms Agrotis ypsilon

Cutworms are the caterpillars of certain moths and are serious pests of tomato seedlings. Cutworm larvae come in various colors and patterns, but always appear smooth skinned to the naked eye. Most species reach 1 to 2 inches when fully grown and usually curl up when disturbed. They are feed on seedlings at night, whereas during the day, they hide in soil, under clods, or in debris at the base of plants. Cutworm damage is more critical after thinning or transplanting.

Fields on bottomland or in low-lying areas bordered by dense vegetation or pastures are more prone to have a cutworm problem. Soil moisture conditions also may influence the type of damage. If the soil surface is dry and crusted, cutworms are more likely to feed on the stalk below ground. Damage below ground is more likely to kill the growing point, which is below ground until the 6-leaf stage. Plants are more likely to survive feeding if damage occurs above the growing point of the plant. A cutworm can cut up to four seedlings before completing its development. Cutworm incidence is often associated with residue of host plants remaining in the field before planting, most cutworm species having a wide host range.

Monitor 5 meter row samples in four locations monitor and determine % cut or damaged seedlings. When 10% of plants are cut or damaged, apply a soil drench. Treatment is warranted when plants are young, and larvae are still 2.5 cm or less in length.

Leaf miner *Liriomyza trifolii*

Small black and yellow leafmining flies make tiny punctures on the side of tomato leaves when feeding and laying eggs. These punctures may serve as entry point for disease-causing organisms, such as bacteria and fungi. The most destructive stages are the immature stages (maggots). Maggots measure up to 3 mm in length and feed on leaf tissue inside the leaf leaving a wandering track in the form of irregular mines. Leaf miners are normally a pest of late season tomatoes and can reach high numbers. Leaf miners reach damaging levels earlier, when infestations begin on seedlings. Young plants can withstand less damage than older ones. Feeding maggots will be found at the end of the mine. When the maggots have already left the mine to pupate, the mine will end with a small convex slit in the epidermis. Occasionally the pupae may be found on the leaf surface, although in most cases they pupate in the soil.

Monitor flies using yellow sticky traps (they also control the pest at low densities) or place plastic trays about 30 x 40 cm in size beneath plants at several randomly chosen places in the field. Mature larvae that drop from foliage accumulate on the trays and pupate there, providing a measure of leaf miner activity. A treatment threshold for fresh market tomato fields is to treat when an average of 10 pupae per tray per day accumulates over a 3- or 4-day period. In all areas, do not treat unless pupae are present since their absence, even if new mines are present, indicates that natural controls are keeping leaf miners controlled.

White fly Bemisia tabaci

Whitefly is a serious pest of tomatoes from seedling to mature stage. It is about 1 mm in size and goes through six stages, namely egg, first, second, third and fourth larval stage (which develops into a pupa) and adult. The adult whiteflies can usually be found in the top of the plant and on the underside of young leaves, where they deposit their eggs. When shaking infested plants, adults will first fly, then return to the underside of the leaves.

Heavy honeydew or mould coating reduces plant growth and fruit quality. Larvae also produce large amounts of wax on and around their dorsal surface. These substances soil the crop and reduce production. However, the main damage caused by whiteflies is indirect as vectors of virus diseases. In particular, it is an efficient vector of the tomato yellow leaf curl virus (TYLCV), a major disease in Africa. Small numbers of whiteflies do not cause major direct plant damage but still may need to be controlled in areas where TYLCV is common.

Cotton aphid Aphis gossypii

This species feeds on a wide variety of plants from members of 25 plant families including beans, citrus, cucurbits, cotton, okra, spinach, and tomato. Aphid population always consists of viviparous females who give birth to nymphs rather than laying eggs on the plants firs. Young grow quickly and molt four times before they become adult. The resulting characteristic white skins betray the presence of aphids. Winged aphids develop at high densities, enabling rapid spread to new fields. In addition, aphids excrete honeydew on which sooty mold can develop, soiling the crop.

Cotton leaf worm Spodoptera littoralis

Cotton leaf worm are olive-green, dark grey or brown with large, black, triangular spots on their back. The fully-grown caterpillars are 3 to 5 cm long. Eggs are laid on leaves in clusters covered with hair-like scales left by the female moth; there may be more than 100 eggs per cluster, but usually there are fewer. Newly hatched larvae feed together on foliage near the egg cluster and gradually disperse as they grow whereas older larvae feed on leaves and fruit. They feed on the leaves of tomato and bores into the fruit, especially those growing down the plant near to the soil. In processing tomatoes, feeding is often shallow and superficial as most wounds eventually dry. Little loss would result when the processing pack is for paste or juice uses, if not for decay organisms that sometimes enter wounds and rot the fruit or when feces or the caterpillar remain in the fruit.

Begin sample at the mid vegetative stage and later both leaves and fruit when monitoring for caterpillars. Sample 20 plants. In the vegetative stage, the threshold is 10 larvae/20 plants but during fruiting, the threshold is 3 larvae/20 plants.

African bollworm Helicoverpa armigera

The African bollworm, also known as the tomato fruit worm, is one of the most destructive insect pests of tomato, causing yield losses as high as 70% due to fruit boring. They prefer green fruit but feeding contaminates the fruit with excreta, exposing them to fungi and bacteria. Fruitworm eggs are laid singly on both upper and lower surfaces of the leaves usually in the upper part of the plant. When first laid they are creamy white, but develop a reddish brown ring after 24 hours and darken just before larvae hatch. Larger larvae vary in color from yellowish green to nearly black and develop fine white lines along the body but retain the black spots at the base of bristlelike hairs. Older larvae also have patches of stubby spines on their body segments that are much shorter than the bristles, and can be seen best with the use of a hand lens. When there is fruit present, the tomato fruitworm will complete its larval development inside fruit. Early-stage larvae enter fruit at the stem end, when it is 2-6 cm in diameter. During development, caterpillars may emerge from one fruit and enter another. Late in the season, small larvae will also enter ripe fruit. They are difficult to detect and, thus, may be a problem in processing tomatoes for the canner. Tomato fruitworm is less of a problem for fresh market tomatoes because damaged fruit are easily culled at harvest.

Monitor carefully for eggs and small larvae. Pheromone traps can be purchased to determine when egg laying has begun. When traps indicate flight has begun, conduct a 5-minute search of leaves for eggs. If eggs are found, a treatment may be warranted. Later in the season, sample both leaves and fruit when monitoring for caterpillars. When control is needed, it is essential to treat before large numbers of larvae enter fruit, where they are protected from sprays. No insecticide controls the mature larvae, therefore, the key is to detect economic densities before the population reaches the last stage larva.

Tomato leaf miner Tuta absoluta

This newly introduced pest moth was first known as a tomato pest in many South American countries. In 2006, it was identified in Spain, the following year it was detected in Morocco, Algeria and Libya and now it is in Niger and will soon spread to all tomato growing areas. It disperses through the wind and people carrying tomatoes

when they travel. *Tuta absoluta* is a very harmful, leaf-mining moth with a strong preference for tomatoes. It also occurs on other crops within the solanaceous plant family namely eggplant, sweet pepper, as well as potato and various weeds in the same family.

Tuta reproduces rapidly, with a life cycle ranging from 24-38 days, depending on temperature. The minimum temperature for activity is 9°C. One female may deposit up to 250-260 eggs during her life on aboveground plant parts. Its larval stage (caterpillars) does not enter dormancy as long as food is available. There are 4 instars that take 8 days to develop before pupation. Young larvae have white or cream colored bodies with a black head, then, they turn pink or green. Larvae mine in leaf tissues, on tomato fruit and stem. Pupation may take place in the soil or on the surface of a leaf, in a curled leaf or in a mine. Overwintering can take place as egg, pupa or adult moth. Adult moths are small body length (7mm), brown or silver with black spots on the wings and live 10-15 days. They are active during night and hide between leaves during the day. *Tuta* can cause 50-100% yield reduction on tomato crops and its presence may also limit the export of the product.

Augmentative biological control has been attempted in Spain by releasing *Trichogramma acheae* in the field at the rate of 750,000 adults/hectare – every 3-4 days to contain the pest. This is an extreme and costly example of a biocontrol success, which is probably uneconomical. The net result is that tomato production is in jeopardy with this new pest.

Monitor the fields with a pheromone trap to detect the adults. As this is an invasive insect pest, few natural enemies are adapted to it so most eggs survive to adulthood. Effectiveness of chemical control is limited to systemic products as the larva feeds within the tissues of leaves. Insecticide resistance also develops rapidly, so a resistance management program needs to be followed where all members of a community rotate insecticide families each season.

Spider mites Tetranychus

Spider mites are a pest in many crops. Their great reproductive capacity enables them to cause enormous damage in a short period of time. It goes through five stages, namely egg, larva, first nymphal stage (protonymph), second nymphal stage (deutonymph) and adult. All stages can be observed in the crop. Their numbers are normally held in check by beneficials such as predatory mites. In a number of crops, spider mites can be the most important pest, often because of intensive use of insecticides that selectively kills its natural enemies in a phenomenon called a secondary pest outbreak. This will no doubt happen when *Tuta absoluta* becomes a major pest of tomatoes in Niger. In field crops, other *Tetranychus* species can also cause damage.

Broad mite Polyphagotarsonemus (= Hemitarsonemus) latus

Please see the Peppers section for general information on this pest.

Fruit Fly

Please see Cucurbits section for general information on this pest.

Tomato				
Insect Pests/Mites	Damage	Available Control Measures	Pesticides	
Cutworms (Vers gris)	They reduce plant stand and weaken plants by cutting holes in the leaves, cutting the stem or severing the base of the plant.	-Deep tillage at least 2 weeks before plantingRemove weeds at least 2 weeks before planting.	Soil drench spinosad, indoxocarb, or imidacloprid (only in locations with most damage).	
			Nuclear polyhedrosis virus	

Leaf miner (Mouche mineuse des feuilles)	Heavy defoliation can kill seedling and reduce the size and number of fruit and flowers. White marks on the leaf surface. Weak plants. Defoliation of tomato plants may also expose fruits to sunburn and affect the market value.	-Install insect-proof nets to protect the nurserySpray substances of garlic, onion, or red pepperConserve leaf miner natural enemies by using selective insecticidesPerform a shallow ploughingDestroy infested transplants and residues and old plantings.	Spinosad, neem seed extract, or spirotetramat. Conserve leaf miner natural enemies by using selective insecticides. Spraying fermented buttermilk 6 litrtd mixed with 100 gr asoefatida. Cow urine spray. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: lambda cyhalothrin and deltamethrin.
Whitefly (Mouche blanche)	Leaves dry out and roll up. Reduced growth. Presence of black wax on attacked organs. Yellowing and weakening of the plants. Shiny or blackened appearance leaves.	-Same as leafminer aboveInstall insect-proof nets to protect the nurseryWater regularly on the foliageDestroy plants residues after the last harvestRemove weeds as soon as possibleMaximize the distance and time interval between host crops. When possible, plant tomatoes at least one-half mile upwind from key whitefly hosts (cucurbits, crucifers, cotton).	Spray neem seed extract, laundry bar soap, or horticultural oil. If greater control is warranted, spray spinosad, flonicamid, pymetrozine, or imidacloprid.
Cotton aphid (Puceron du coton)	Leaves are curled, yellow, dry and distorted. Plants are small. Presence of black wax on attacked organs. Reduced number and size of fruit and reduced fruit quality.	-Same as leafminer aboveInstall insect-proof nets to protect the nurseryWater regularly on the foliage.	Horticultural oil, neem seed extract, chili extact, or soap.
Cotton leaf worm (Noctuelles du cotonnier)	Defoliation and boring into fruit. Single or closely grouped circular or irregular holes on leaves.	-Hand remove egg massesRemove weeds early in the crop.	Bacillus thuringiensis, neem seed extract, or chloranthraniliprol e EC for small to mid-sized larvae.

African bollworm/Tomato fruit worm (Ver du fruit de la tomate)	Fruits become rotten and have big holes and caterpillars are inside. Messy, watery, internal cavities filled with cast skins and feces. Damaged fruit will ripen prematurely.	-Do not plant near other solanaceae/maize/cotton. -Use insect pheromone traps. -Handpick worms. -Remove attacked fruits. -Plant early-season fields. -Complete shallow ploughing after the last harvest.	Chloranthranilipr ole, methoxyfenozide, or indoxacarb for middle-sized larvae. Begin spraying when the larvae are first noticed and spray 2-3 times at 10-day intervals If young larvae, then use Bacillus thuringiensis or neem seed extract. If older larvae, use chloranthraniliprol e, methoxyfenozide, indoxacarb, tebufenozide, or nuclear polyhedrosis virus. Chilli-garlic extract.
Tomato leaf miner (Mouche mineuse des feuilles)	Leaves turn brown. Blotch-shaped mines in the leaves, where both the caterpillars and their dark excreta can be found. In case of serious infection, leaves die off completely. Malformation and damage to fruit, rotting fruit before or after harvest.	-Remove crop residuesAlternate weed hosts in the solanaceae family.	Spinosad, indoxacarb, Bacillus thuringiensis, or neem.
Spider mites (Araignée rouge)	Produce silver yellow spots, leaves wilt and dry. Brown areas on stems. Fruits with crackled aspect.	-Install windbreaks around the fieldLeave a distance between the crop and the field bordersFavor sprinkling irrigation on leavesWeed the fieldRemove crop residues after harvest.	Horticultural oil, sulfur WP (to enhance the efficacy of the sulfur spray mixed with canola oil at 9 grams/liter sulfur

			and 0.5 ml/liter canola oil).
Broad mite (Tarsonème)	Sucks the sap of leaves that become dwarfed, batches and bended. Veins are big and sinuous. Fruits get stripes, buds fall down.	-Favour sprinkling irrigation on leavesLeave a distance between the crop and the field bordersRemove crop residues after harvest.	Neem seed cake. Sulfur and canola oil (9 grams sulfur and 0.5 ml/liter of canola oil). Horticultural oil.
Fruit fly (Mouche des fruits)	Fruits rotten and if open contain several maggots.	-Use insect traps (sticky or hormonal)Remove attacked fruitsComplete a shallow ploughing.	

Diseases

Damping off fungi Phytophthora, Pythium, and Rhizoctonia spp.

Please see millet/sorghum and groundnut sections on this pest.

Bacterial wilt Ralstonia (= Pseudomonas) solanacearum

Bacterium wilt lives in moist sandy soil and will work its way quickly through the roots and up the stem of the plants. Nematodes cause wounds allowing entry. Bacteria clog vascular tissues leading to death of plant. Bacterial wilt often happens where plants have been cut, injured or weakened by insects. The bacterium clogs up the stem, preventing water and nutrients from reaching the leaves and the plant dies. The first symptoms of wilting in youngest leaves, usually occurs during the hottest part of the day. This can easily go unnoticed because the leaves stay green. These dramatic symptoms occur when the weather is hot, the humidity is high and lots of rainfall has left the soil moist to wet. Total collapse of the plant usually occurs when temperatures reach > 32°C. It is also more common in soil with a high pH. One can diagnose bacterial wilt by cutting the stem at the base of the plant. Look for discolored tissue. Suspend the stem in a glass of water. Plant hosts include: potato, eggplant, tobacco, and sweet pepper.

Control of bacterial wilt in infested soils is difficult. There is no effective pesticide against this bacterium.

Bacterial spot Xanthomonas campestris pv. vesicatori

Bacterial spot is another serious disease, occurring during the rainy season. It is most noticeable on fruits, but also causes damage to the foliage and stems. Bacterial spot develops on seedlings and mature plants. The disease is transmitted through the seed or transplants. The bacterial spot bacterium persists from one season to the next in crop debris, on volunteer tomatoes, and on solanaceous weed hosts. Secondary spread within a field occurs by splashing water from sprinkler irrigation or rain. Infection is favored by high relative humidity and free moisture on the plant. Symptoms develop rapidly at temperatures of 68°F (20°C) and above. Night temperatures of 61°F (16°C) or below suppress disease development regardless of day temperatures. Some pathogen strains are virulent on either tomato or pepper and some may be virulent on both.

Fusarium wilt Fusarium oxysporum f. sp. lycopersici

The Fusarium wilt fungus infects plants through the rootlets, invading the xylem and eventually extending throughout the plant. Leaflets on one side may be affected while those on the other side are symptomless. Symptoms often first appear during fruit sizing. Fusarium wilt can greatly reduce yields in fields with a high incidence of Fusarium. Long distance spread is by seed, transplants, and soil on farm machinery.

The fungus overwinters and survives for many years in the soil as spores. The disease is favored by warm weather. It causes most damage on light, sandy soils. It is most active at temperatures between 25 and 320 C.

The fungus can survive in the soil indefinitely even when no tomatoes are grown. It can also survive in fibrous roots of weeds (eg. Amaranthus, Digitaria and Malva species). Excessive nitrogen fertilization promotes disease development. Infestation by root-knot nematodes encourages the disease. No fungicides are effective against this pathogen.

Early blight Alternaria solani

Plants infected with early blight develop small black or brown spots on leaves, stems, and fruit. Insects, wind, and human contact spread the spores. During rainy weather or overhead irrigation, spores quickly spread the disease through the patch. The disease is favored by warm wet weather and moist 48-hour period is required for infections to occur. The fungus can over-winter on diseased plant debris and in perennial weeds. These serve as sources for inoculum and for primary infections in the spring. Fungal spores are easily water-splashed from one leaf to another, and they depend on standing water on the plant surface to cause infections. If the disease is spreading rapidly treat the field with mancozeb.

Cercospora leaf spot Pseudocercospora fuligena

Development of cercospora leaf spot disease begins when the fungus' spores are dispersed by rain, irrigation water and wind. Germination occurs in humid conditions and fungus growth is encouraged by frequently damp leaves from dew. In general, the more rain, the worse the disease spreads. Cercospora infests seeds and crop residue where it harbors over the winter.

Treating existing cercospora leaf spot disease on crops can be challenging due to the fungus' ability to live in ground residue and its dispersion method which is affected by uncontrollable weather conditions. If Cercospora leaf spot is increasing in plant coverage apply manzoceb or sulfur.

Powdery mildew Leveillula (=Oidiopsis) taurica

A gray fungal growth develops on the lower leaf surface of infected leaves. Severe infections kill leaves and result in sunburn fruit and weakened plants. Plants will have a lower yield and shortened fruiting season. Loss in fruit production is due to early senescence. The fruit flavor will not be as strong as it would have been without the fungal infection. Tomatoes can be infected at any stage; however the disease usually occurs late in the season. High relative humidity and warm, shady weather favors disease development. Mild temperatures favor infection while higher temperatures hasten the death of infected leaves. Powdery mildew infection develops when wind borne spores land on plant tissues. When the disease is noticed and is spreading, a fungicide application may be necessary to control powdery mildew. Sulfur wettable powder or neem seed oil sprays are usually effective.

Late blight Phytophthora infestans

Leaf symptoms first appear as small, water-soaked areas that rapidly enlarge to form purple-brown, oily-appearing blotches. On the lower side of leaves, rings of grayish white mycelium and spore-forming structures may appear around the blotches. Entire leaves die and infections quickly spread to petioles and young stems. Symptoms usually begin on the shoulders of the fruit because spores land on fruit from above. Infected fruit turn brown but remain firm unless infected by secondary decay organisms. Late blight occurs when humid conditions coincide with mild temperatures for prolonged periods. Spores of the fungus are easily spread by wind to other plants.

Fungicides are generally needed only if the disease appears during a time of year when rain is likely or overhead irrigation is practiced. Apply approved pesticide when disease symptoms are on 5% of the crop.

Anthracnose Colletotrichum coccodes

Anthracnose of tomatoes is primarily a disease of ripe and overripe fruit. The fungus is a parasite and generally infects ripe or overripe fruit and roots of mature plants. The disease affects fruit infrequently. The fungus can infect both green and red fruit and is able to penetrate the cuticle of uninjured fruit. When green fruit is infected, it does not show spotting until it begins to ripen. Tomato fruit become increasingly susceptible as they approach maturity. On ripe fruit, lesions become visible within 5 to 6 days after infection. The fungus

survives the winter as seed-like structures called sclerotia and as threadlike strands called hyphae in infested tomato debris. In late spring the lower leaves and fruit may become infected by germinating sclerotia and spores in the soil debris. Infections of the lower leaves of tomato plants are important sources of spores for secondary infections throughout the growing season. Senescent leaves with early blight infections and leaves with flea beetle injury are especially important spore sources because the fungus can colonize and produce new spores in these wounded areas.

If disease is spreading, apply approved fungicide when fruit are formed on the first cluster.

Tomato yellow leaf curl virus (TYLCV)

The virus only affects tomato and pepper and is transmitted in the whitefly vector *Bemisia tabaci*. TYLCV can spread rapidly, but TYLCV is not transmitted through seed rather by mechanical transmission or transovarially in the vector. The primary way the virus is spread short distances is by the whitefly. The presence of whitefly host plants, both cultivated (peppers and tomatoes) or weeds may lead to whitefly migration and spread of TYLCV. Over long distance, the virus is primarily spread through the movement of infected plants, especially tomato transplants. Because it can take up to 3 weeks for disease symptoms to develop, infected symptomless plants could be unknowingly transported. TYLCV can have a severe impact on tomato production. Plants infected at an early stage will not bear fruit and their growth will be severely stunted.

In a TYLCV endemic area, apply imidacloprid as a soil application or through the drip irrigation system at transplanting. After the efficacy of the insecticide application has dissipated due to crop growth, the secondary spread of whiteflies will need to be controlled. Monitor whitefly populations throughout the season, treating when there is one whitefly per 10 plants.

Cucumber Mosaic Virus (Virus de la Mosaïque du Concombre) (CMV)

See the Cucurbits section for general information on this pest.

Tobacco Mosaic Virus (TMV)

Tomato plants infected with tobacco mosaic virus (TMV) vary with the cultivar and the specific virus or strain. A mild mosaic develops on leaves with some leaf malformation, including a fernlike appearance. TMV is easily mechanically transmitted. There are many sources of the virus, including tobacco products, tomato seed, infected plant debris, and equipment; the virus is not transmitted by insect, nematode or fungal vectors. TMV is very stable viruses and can TMV is viruses are seldom seen in direct-seed fields. Use seed that has been treated to eliminate seedborne inoculum. Extreme sanitation is needed. The disease is difficult to control if the plants have to be handled. Some cultivars have genetic resistance.

Tomato			
Disease	Damage	Available Control Measures	Pesticides
Damping off	Causes death and wilting	-Crop rotation.	Fluopicolide or
fungi	of the young plants.	-Avoid wet soils.	fosetyl-
(Fonte des	Surviving plants may	-Favor good drainage and good soil aeration.	aluminum.
semis)	have reduced growth and	-Water only when soil is dry.	
55157	yellowing leaves. A fine		Soil application
	white powdery (the		of neem cake
	fungus) can be seen at		both in nursery
	the soil surface.		and main field.
			Is also a
			preventive
			method.

			Seed treatment: thiamethoxam, mefenoxam, and difenocona zole. Seed treatment: Mancozeb or thiram.
Bacterial wilt (Flétrissement bactérien)	Plant wilts and internal part of the stem gets brown. Death of the entire plant without any yellowing or spotting of leaves. Leaves bent downward, adventitious roots growing in the stems, and narrow dark stripes beneath the epidermis, mainly the xylem. White slimy viscous ooze typically appears on transverse-sectioned stems at the points corresponding to the vascular bundles.	-Certified seeds or sterilize seedCrop rotation of appoximately 3 years avoiding successive solanaceae cropsResistant varietiesAvoid working on infested soilAvoid irrigating with water passing through contaminated fieldsRemove infested plants and residuesGood soil drainage/raised beds and plant on ridgesControl root knot nematodes as to prevent pathogens from enteringSpace plants far enough apart for good air circulationWash hands after handling infected plants and sterilize any potentially infected gardening toolBurn a fire over the area for the seedbed to sterilize the soil using brushwoodAvoid using diseased transplantsMake furrows and sow seeds far apartProtect developing seedlings from the hot sunGraft seedlings onto wild eggplant rootstock that has natural resistance Avoid high moisture.	Neem cake application to soil.
Bacterial spot (Galle bactérienne)	Attack leaves, stems and fruits and cause little dark spots with angular shape that coalesce and cause yellowing, decline and leaf drop. Elongated spots can also appear on stems. Brown spots can also appear on fruits.	-Crop rotation: if infestation, no solanaceae during 2/3 yearsRemove crop residuesAvoid overhead wateringUse resistant varietiesUse pathogen-free seed and disease-free transplantsAvoid working in the field when the plants are wetAdd compost to the seedbed and in planting holes at transplanting.	
Fusarium wilt (Flétrissement fusarien)	Branches or whole plant wilts from the bottom to the top. Yellowing on one side of the plant which withers and dies. Browning of the inside part of the stem. Roots stunt. When affected stems just above ground level and petioles are cut	-Resistant varietySterilize nursery bed soil by burningIncrease soil pH to 6.5 to 7.0 with lime or compostCrop rotation of 3/4 years without cucurbits if infestationRemove crop debris after harvestingClean farm equipmentAvoid root knot nematode infestationsDo not locate seedbeds on land where Fusarium wilt is known to have occurred.	No fungicides are effective. Neem cake application as a preventive mechanism

	diagonally, a reddish- brown discoloration of the water conducting tissues will be observed. A dark brown vascular discoloration extends far up the stem.		
Early blight (Alternariose)	Circular and up to 12 mm in diameter, brown spots. First black spots with yellow borders appear on leaves, then larger brown spots. On fruit spots start at the attachment point. Spots on fruit are sunken, dry, and may also have a concentric pattern. Symptoms typically appear soon after fruit set, starting on the lower leaves. Eventually, leaves turn brown and drop off.	-Resistant variety and disease-free seeds Remove crop debris and infected leavesDisinfect seedsCrop rotation of 3/4 yearsAvoid watering the foliage at the end of the day or at nightAvoid working with plants that are wetMinimal spacing of 0.7meters apartUse a straw mulch to help protect the plant from inoculum splashing from the soil onto lower leavesRemove leaves in the lower 20-30cm of the plant (as the plant grows) -Avoid overhead sprinkling on tomatoesFertilize lightly as the first fruits reach 5cm in diameter (every two weeks on a sandy soil)Avoid heavy nitrogen applicationsKeep the field weed-freeIf using one's own seeds, soak for 20 minutes in 5% sodium hypochlorite disinfectant.	Mancozeb.
Cercospora leaf spot (Cercosporiose)	At first tiny circular or oval spots on leaves that enlarge with time. Dark green or brown round spots surrounded by a yellow ring on young plants, but turn white on older crop. Leaves turn yellow then wilt and fall. Elongated spots on stems.	 Use healthy seeds. Remove crop residues and infested plants. Avoid overhead watering, otherwise water early in the morning. Crop rotation of 3/4 years with for example sorghum, maize, or fodder plants. Plant disease-free transplants far enough apart so that they will not be crowded after fully grown. Avoid working with plants when foliage is wet. Water at the base of the plants, and in the morning rather than the evening. Weed fields frequently. 	Mancozeb (3 grams/liter is most effective).
Powdery mildew (Oïdium ou Blanc)	White powdery film and yellow/brown spots on the leaves/stems, they can dry and become brittle. Irregular, bright yellow blotches on leaves. Spots of dead tissue, sometimes surrounded by a yellow halo, eventually appear in the blotches. The leaves will then turn yellow, die and drop off.	-Remove weeds and plant residuesPractice overhead wateringEnsure full-sun conditions and high temperaturesChoose resistant varietiesProvide proper air circulation around the tomato plantsAllow for adequate spacing in the gardenRotate every 3 years with non-solanaceous crops.	Mancozeb, sulfur, or clove oil. Neem oil mixed with starch.

Late blight (Mildiou)	Irregular oily green-black spots that later turn brown on leaves and stems. Fruits get dark, harder with a lumpy shape.	-Remove crop debris and burn infested plantsUse resistant varietyAvoid overhead wateringUse disease-free transplantsStake and prune indeterminate varietiesRemove any nearby volunteer solanaceous plantsPlow under plant debris after harvestRotate every 3 years with non-solanaceous crops.	Fluopicolide. Fosetyl- aluminium or mancozeb. Apply sulfur treatment before first rain and every 5 days.
Anthracnose (Pourriture rouge)	Causes round and concave spots 1.2 cm in diameter with orange/light brown concentric pattern at their center. With age the lesions become tan and dotted with small black specks. During moist weather, masses of orange-red spores may form on the lesion surface. Infection may also occur on stems, leaves, and roots.	-Use healthy seedsRotation every 3 years with non-solanaceae cropsAvoid overhead wateringHarvest fruits as soon as ripeRemove attacked plants/fruitsPlant tomatoes on well-drained landMulching around the tomato plantsStaking tomatoesDeep plow or till tomato debris into the soil after the last fall harvest.	Mancozeb.
Tomato yellow leaf curl virus (Virus de l'enroulement foliaire jaune de la Tomate) (geminivirus) (TYLCV)	Edges of leaves turn yellow, upward leaf cupping, leaf mottling, reduced leaf size, stunt plants, and flower drop.	-Resistant varietyRogue infected plantsCover seedbed with mesh to prevent vector contactIsolate new crop form contaminated cropCreate a 2-3 month host-free period to cleanse the virus from the areaRotate insecticide classes for insecticide resistance management.	See whitefly information.
Cucumber Mosaic Virus (Virus de la Mosaïque du Concombre) (CMV)	Leaves have mosaic aspect light to dark green. Also fraying and stricture of leaves. Flowers can fall and fruits be wrinkled and bumpy, and sometimes have yellow to black rings.	-Protect nursery with an insect-proof netWeed the plot and remove contaminated plants.	
Tobacco Mosaic Virus (Virus de la Mosaïque du Tabac) (TMV)	Mosaic, mottled, bended and frayed leaves. Greenish rings and necrotic areas on fruits.	-Use healthy seedsGrow resistant varietiesCrop rotation of 2 years without solanaceae or cucurbitsWeed the plot and eliminate contaminated plantsDo not touch healthy plants after touching contaminated plants and disinfect tools.	

Nematodes

Root knot Meloidogyne spp. and sting nematode, Belonolaimus longicaudatus

Root-knot nematodes are very destructive to tomatoes. Damage is most serious on light sandy soils in furrow-irrigated crops. Nematodes cause small lumps known as root knots or galls up to 2.5 cm in diameter on the roots and appear as irregular patches. Root knot nematodes spend most of their life in galls. Sting nematodes typically feed on root tips. Mature females resemble tiny, white pearls; they sometimes can be seen with the use of a hand lens when root galls are cut open. Galls interfere with the flow of water and nutrients to the plant. Under heavy nematode infestation, crop seedlings or transplants may fail to develop, maintaining a stunted condition, or die, causing poor or patchy stand development. Under less severe infestation levels, symptom expression may be delayed until later in the crop season after a number of nematode reproductive cycles have been completed on the crop. In this case aboveground symptoms will not always be readily apparent early within crop development, but with time and reduction in root system size and function, symptoms become more pronounced and diagnostic.

Check the roots of a few plants in midseason or later, even if the crop appears healthy. Check earlier if you see wilting, poor growth, or other symptoms; galls may appear as soon as a month after planting.

Tomato			
Nematode	Damage	Available Control Measures	Pesticides
Root knot	Plants wilt,	-Weed management.	Spirotetramat.
nematode	leaves become	-Crop rotation and intercropping.	Spray into roots.
(Nématode à	yellow and	-Plant trap-plant like groundnut before crop.	
galles)	appearance of	-Mix cropping or cover cropping with non-	Neem cake
	root galls/knots	host crops.	application.
	of different	-Field solarization (a transparent	
	sizes and	polyethylene film is laid over moist soil for a	
	infected roots	6-to-12-week period to heat).	
	also become	-Flood the plot.	
	enlarged and	-Use manure in nursery.	
	distorted.	-Avoid growing on an infected plot.	
		-Dig up and let drying attacked plants.	
		-Use tomato varieties resistant to nematodes	
		where they are present. Effective against M.	
l		incognita, M. javanica, and M. arenaria.	

PEPPERS

European explorers and slave ships brought chili peppers, native to S. America, to West Africa. Chili peppers more than sweet peppers are in the cuisines in West Africa. Many dishes are enriched with a base of tomatoes, onions and chili peppers, considered as a starter for cooking many dishes. The bite and fire of these extremely hot peppers add a unique flavor as well as heat. The chili is also supposed to help preserve food, as well as adding flavor to relatively bland tropical staples like root vegetables. Most peppers are consumed as part of the national diet but some is exported. There is one harvest per year in the project area.

Cutworms Agrotis ipsilon, Spodoptera spp.

Cutworms have solitary habits and feed on pepper seedlings at ground level, cutting off the stem and sometimes dragging the plants into their burrows. Most of the plant is not consumed but merely eaten enough to cause it to topple. Since the larvae lie burrowed near the roots of the host, they sometimes feed on roots and the below ground stem. Because of the nature of their feeding on young plants, this pest can do great damage in newly planted fields. Larvae remain below the surface of the ground, under clods of soil, or other

shelter during the day and feed at night. The first two larval stages feed on the foliage of the plant. The third up to the fifth stages often become cannibalistic and thus adopt solitary habits.

Cotton aphid Aphis gossypii, Green peach aphid Myzus persicae

Cotton aphid and green peach aphid occur in colonies initially around the very nutritious growing points, young stems and leaves, flower buds as well as on the lower leaf surface. Aphids damage plants in three ways: 1) by sucking their sap, 2) excreting a sticky substance (honeydew) that coats the plants, and 3) by transmitting viral diseases. Growth of sooty mold on honeydew excreted by aphids reduces photosynthesis and affects fruit quality. Aphids cause indirect damage as vectors of important viruses in West Africa such as chili veinal mottle, pepper mottle, pepper severe mosaic, pepper veinal mottle. It is not known which of these occur in Niger.

The green peach aphid is among the most common aphid species found on peppers. It may be present at any time throughout the year. Generally its color is pale green, although at times individuals may be pinkish. Damaging levels are characterized by large numbers of aphids found on the underside of leaves. Honeydew produced by the aphids can be a problem, especially on fresh market peppers. Aphid damage is most prominent on newer, younger leaves in the center of the plant. Aphids are vectors of pepper leaf curl virus.

Onion thrips Thrips tabaci

Thrips are small, slender insects that are best seen with a hand lens. Adults are pale yellow to light brown in color. Immature stages have the same body shape as adults but are lighter in color and are wingless. Hosts aside from pepper include onion, tomato, lettuce, and beans. Adults and nymphs suck the young leaves and young stems. Thrips pupate in the soil. Life span is about 14 to 30 days depending on the environmental factors when conditions are dry life cycle is completed in short period.

Whitefly Bemisia tabaci

Whitefly immature stages (nymphs) and adults suck sap from leaves. Nymphs excrete a clear sugary liquid known as honeydew, which often completely covers the leaves during heavy infestation. Honeydew supports the growth of a black sooty mould, and as a result the leaves may turn black, affecting photosynthesis. Whiteflies are vector of important viral diseases such as tomato yellow leaf curl virus TYLCV.

False codling moth Thaumatotibia (Cryptophlebia) leucotreta

The false codling moth is approximately 1 cm in length. Its larvae have been recorded feeding on more than 50 species of plants in over 30 families. It is one of the most commonly intercepted tortricids on sweet pepper and eggplant fruit at US ports-of-entry. It is a pest of mainly citrus, mango, guava, avocado, and cotton throughout Africa. The eggs are deposited on the surface of the host fruit over irregular intervals throughout the female's life. Once hatched from the eggs the larvae burrow a 1 mm diameter hole into the host fruit. A discoloration appears at the wound site as a sign that secondary microorganisms have entered the wound. Once the larvae are inside the pulp they begin to feed. Young larvae feed on the outer portion while older ones move further into the interior of the fruit. Only a few larvae may survive per a fruit. Once the fruit has been penetrated it is no longer a marketable item. They pupate in a silken cocoon in the soil, or under leaf litter.

Mediterranean fruit fly Ceratitis capitata

The adult medfly is 0.4 cm long which is about 2/3 the size of a housefly. The general color of the body is yellowish with a tinge of brown, especially the abdomen, legs, and some of the markings on the wings. Damage to crops caused by Mediterranean fruit flies result from 1) oviposition in fruit and soft tissues of vegetative parts of certain plants, 2) feeding by the larvae, and 3) decomposition of plant tissue by invading secondary microorganisms. Fruit fly females lay eggs under the epidermis of the fruit. Several eggs may be laid on each fruit. After emerging from eggs, maggots generally move to the core to feed. When infested fruit is picked, the cap usually separates from the fruit because the maggot has eaten the core. Maggots remain in peppers until fully grown (from 2 to 3 weeks). At this time the maggot leaves the pepper, drops to the soil to pupate. Yield losses can be considerable. One maggot can destroy an entire fruit. This pest attacks more than 260 different fruits, flowers, vegetables and nuts. Thin-skinned, ripe, succulent fruits are preferred.

African bollworm Helicoverpa armigera

Soon after hatching, the larvae burrow into the fruit, usually near the calyx, and remain inside, feeding on the flesh. Infested fruit decay, turn red, and fall off the plant early, reducing yield. Larvae consume very little foliage.

Spider mites Tetranychus spp

See section on Okra for general information on this pest.

Broad mite or chili mite Polyphagotarsonemus (= Hemitarsonemus) latus

Broad mites are tiny (0.1-0.2 mm long) and oval shaped. They can barely be seen with the naked eye. A generation takes about 1 week under optimal conditions and females deposit 40 each. The usual sex ratio is 1:4 male: female. Dispersal is by winds and on the bodies of other insects especially whiteflies.

An attack by the broad mite can be detected by the symptoms of damage. They live on the underside of leaves, tender stems, fruits, flower peduncles and flowers. The mite's toxic saliva causes twisted, hardened and distorted growth in the terminal of the plant. Initial attack occurs on the stems of terminal shoots and the lower surface of young leaves. Mites are usually seen on the newest leaves and small fruit. Severely infected fruits fall, and yield is significantly reduced. Symptoms remain for a long period of time after control.

Leaf miner Liriomyza trifolii

Please see tomato section on this pest.

Pepper			
Insect Pests/Mites	Damage	Available Control Measures	Pesticides
Cutworms (Vers gris)	Larvae cut off young plants, feed on seedlings and roots.	-Manual collection of the larvae. In small plantings, it should be sufficient for control.	Bacillus thuringiensis, indoxocarb, imidacloprid (only in locations with most damage), or nuclear polyhedrosis virus.
Aphids (Pucerons)	Leaves are yellow, dry and distorted. Chlorotic spotting and molting of older leaves. Plants are small, are stunted and wild. Presence of black wax on attacked organs.	-Install insect-proof nets to protect the nurseryGood field sanitationPlowing under or removing crop debris immediately after harvestDestruction of alternate host plantsWater regularly on the foliageEarly plantingGood nutrition for the plant.	Neem seed extract, chili extact Or soap. Horticultural oil Ferment 5 kilograms of neem seed
			extract and 5 liters cowurine and 1kg cowdung for 24 hours and after filtering.

			Make it for 100 liters.
Onion Thrips (Thrips)	End of leaves dry, and leaves get small silvery stains and curl, roll up and eventually fall. Distortion as and necrosis of young flowers and fruits. Plant growth distortion. White streaks can be seen in fruits when damage fruits and fruits malformed.	-Tolerant varietyWater plants regularlyMulch the soil with plant residuesPlough the landEliminate weedsUse traps Avoid planting peppers next to onions, garlic, or cerealsMulching.	Neem seed extract, spinosad, soap solution, or horticultural or neem oil. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: deltamethrin.
Whitefly (Mouche blanche)	Leaves dry out and roll up and get chlorotic spots. Reduced growth. Presence of black wax on attacked organs.	-Install insect-proof nets to protect the nurseryWater regularly on the foliageDestroy plants residues after the last harvest.	Spray neem seed extract, laundry bar soap, or Horticultural oil. If greater control is warranted spray spinosad, pymetrozine, or
False codling moth (Faux carpocapse)	Larvae tunnel into fruit. A discoloration appears at the wound site.	-Control by destroying all damaged and fallen fruit.	imidacloprid. Tebufenozide. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: deltamethrin.
Mediterranean fruit fly (Mouche des fruits)	Larvae tunnel into fruit. Secondary rot and premature fruit fall. Small dimple where the female fly deposited an egg on infested fruits. Soft spots can often be seen where the maggot has fed on the fruit. Mature attacked fruits may develop a water soaked appearance.	-Bagging the fruit to exclude egg layingField sanitation directed toward the destruction of all infested fruitsBury infested fruit 3 feet under soil surface with an addition of sufficient limeHarvesting fruit weeklyMass collecting of fruitfliesEarly harvest of fruitUse traps with trimedlure to attract the males (control measure if many farmers set out traps in an area).	Fruit fly bait and spinosad. Neem oil spray at the time of flowering effectively controls the eggs. Farmers can contract the government to spray ULV (ultra low volume)

			products to large outbreaks: malathion.
African bollworm/Tomat o fruit worm (Ver du fruit de la tomate)	Fruits become rotten, turn red and have big holes and caterpillars are inside. Eventually they fall.	-Do not plant near other solanaceae fieldsUse insect pheromone trapsHandpick wormsRemove attacked fruitsComplete a shallow ploughing after the last harvest.	If young larvae, then use Bacillus thuringiensis or neem seed extract. If older larvae, use chloranthranilipr ole, methoxyfenozide, indoxacarb, tebufenozide, or nuclear polyhedrosis virus.
Red spider mites (Araignée rouge)	Produce silver yellow spots, leaves wilt and dry. Brown areas on stems. Fruits with crackled aspect.	-Install windbreaks around the fieldLeave a distance between the crop and the field bordersFavor sprinkling irrigation on leavesWeed the fieldRemove crop residues after harvest.	Sulfur WP or horticultural oil.
Broad mite (Tarsonème)	Sucks the sap of leaves that become dwarfed, batches and bended, turn coppery or purplish. Veins are big and sinuous. Fruits get stripes, buds fall down. Discoloration, necrosis of tissues, and deformation. Older leaves are generally cupped with corky brown. The blooms may abort and plant growth may be stunted. The succulent part of the stem of young plants may become slightly swollen, roughened or russeted.	-Favor sprinkling irrigation on leavesLet a distance between the crop and the field bordersRemove crop residues after harvest.	Neem seed cake, sulfur, horticultural oil, or neem oil. Sulphur and canola oil.
Leaf miner (Mouche mineuse des feuilles)	Heavy defoliation can kill seedling and reduce the size and number of fruit. White marks on the leaf surface.	,-Install insect-proof nets to protect the nurserySpray substances of garlic, onion or red pepperPerform a shallow ploughingDestroy infested transplants and residues.	Spinosad, neem seed extract, or spirotetramat. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: deltamethrin and

	lambda
	cyhalothrin.

Diseases

Anthracnose Colletotrichum graminicola

Please see millet/sorghum section on this pest.

Damping off fungi Pythium, Rhizoctonia, Fusarium

Please see millet/sorghum and groundnut sections on this pest.

Bacterial wilt Ralstonia solanacearum

Please see tomato section on this pest.

Fusarium wilt Fusarium oxysporum f. sp. lycopersici

Please see tomato section on this pest.

Powdery mildew Erysiphe cichoracearum

Please see okra section on this pest.

Late blight Phytophthora capsici

Late blight is a widespread fungal disease of pepper. Phytophthora blight of peppers can attack the roots, stems, leaves, and fruit, depending upon which stage plants are infected. Symptoms include rapid wilting and death of pepper plants. Close examination of the roots and stems is necessary to confirm the cause of disease. The disease can develop at any stage of pepper plant growth. The most striking difference between healthy and diseased plants is the total amount of root tissue. A lesion can girdle a stem, resulting in wilting of plants above the lesion and subsequent death. However, both can survive in soil for long periods as thick-walled spores. Contaminated transplants or soil-borne inoculum are sources of primary infections. Irrigation water often disseminates fungal propagules from infested areas to other parts of the field. Thus, irrigation can significantly increase the incidence and severity of root and crown rot in pepper. Infections that occur late in the season may reduce vigor and yield of plants without killing them. In addition, if the foliage wilts during the hottest time of the day and exposes fruit to the open air, such fruit can become sunburned and therefore unharvestable.

Bacterial spot Xanthomonas campestris pv. vesicatoria

Please see tomato section on this pest.

Tomato leaf curl virus (TLCV) and Pepper veinal mottle virus (PVMV)

The symptom of leaf curling was always a common one on peppers. The plant sucking of broad mites, aphids and thrips can produce the characteristic leaf curling symptom. Today as there are many known viruses that produce similar symptoms lead people to conclude that a virus or viruses is responsible. It is known that the TLCV also attacks peppers and is probably the main cause of leaf curling in Niger. But there is also the pepper veinal mottle virus PVMV that is reported to be the most important pepper viruses in West Africa. TLCV is vectored by Bemisia tabaci whitefly while PVMV is transmitted efficiently in the non-persistent manner by *Myzus persicae* and *Aphis gossypii*. PVMV can be acquired and inoculated in 2 min feeding periods and is not seed borne. High temperature and dry weather favor the pathogen.

Cucumber Mosaic Virus (Virus de la Mosaïque du Concombre) (CMV)

See the Cucurbits section for general information on this pest.

Tobacco Mosaic Virus (TMV) See Tomato section for general information on this pest.

Pepper				
Disease	Damage	Available Control Measures	Pesticides	
Anthracnose (Pourriture rouge)	Disease infects overripe fruit. Causes round and concave spots with orange/light brown concentric pattern at their center.	 -Use healthy seeds. -Crop rotation of 3 years without solanaceae. -Avoid overhead watering. -Harvest fruits as soon as ripe. -Remove attacked plants. 	Mancozeb.	
Damping off fungi (Fonte des semis)	Causes death and wilting of the young plants. Surviving plants may have reduced growth and yellowing leaves. A fine white powdery (the fungus) can be seen at the soil surface.	-Crop rotationAvoid wet soilsFavor good drainage and good soil aerationUse treated seedsWater only when soil is dry.	Fluopicolide or fosetyl-aluminum. Seed treatment: mancozeb, thiram, or ash. Seed treatment: thiamethoxam, mefenoxam, and difenoconazo le.	
Bacterial wilt (Flétrissement bactérien)	Plant wilts and internal part of the stem gets brown.	-Certified seeds or sterilize seedCrop rotation avoiding successive solanaceae cropsResistant varietiesAvoid working on infested soilAvoid irrigating with water passing through contaminated fieldsRemove infested plants and residuesGood soil drainage.	Neem cake application.	
Fusarium wilt (Flétrissement fusarien)	Branches or whole plant wilts from the bottom to the top. Yellowing on one side of the plant which withers and dies. Browning of the inside part of the stem. Roots stunt.	-Resistant varietySterilize nursery bed soil by burningIncrease soil pH to 6.5 to 7.0 with lime or fertilizerCrop rotation of 3/4 years without cucurbits if there is an infestationRemove crop debris after harvesting.	No fungicides are very effective. Neem cake application.	
Powdery mildew (Oïdium ou Blanc)	White powdery film and yellow/brown spots on the leaves, they can dry and become brittle.	-Remove weeds and plant residuesPractice overhead watering.	Seed treatment: thiamethoxam, mefenoxam, and difenoconazo le. Once the damage is seen, apply sulfur and canola oil.	

			Neem oil and starch.
Late blight (Mildiou)	Irregular oily green-black spots that later turn brown on leaves and stems. Fruits get dark, harder with a lumpy shape. Taproots and smaller lateral roots show water—soaked, very dark brown discoloration of surface and vascular tissues. Very few lateral roots remain on diseased plants and the taproots may also be shorter.	-Remove crop debris and burn infested plants2 year crop rotation that excludes susceptible plantsUse resistant varietyAvoid overhead wateringEnsure proper irrigationEmploy proper field and seedbed preparationUse practices that reduce or alleviate soil compactionIf possible, avoid planting when the soil is cool.	Fluopicolide, fosetyl-aluminium, or mancozeb. Apply sulfur treatment before first rain and every 5 days.
Bacterial spot (Galle bactérienne)	Attack leaves, stems and fruits and cause little dark spots with angular shape that coalesce and cause yellowing, decline and leaf drop. Elongated spots can also appear on stems. Brown spots can also appear on fruits.	-Crop rotation: if infestation, no solanaceae during 2/3 yearsRemove crop residuesAvoid overhead wateringUse resistant varietiesCertified seedSterilize seed in 50 degree Celsius water.	
Tomato yellow leaf curl virus (Virus de l'enroulement foliaire jaune de la tomate) (TYLCV) Pepper leaf curl virus (Virus de l'enroulement foliaire du poivron) (PLCV)	Vector of TYLCV is whiteflies while that of PLCV are aphids. Edges of leaves turn yellow, leaf mottling, reduced leaf size, stunt plants.	-Fire ashResistant varietyRogue infected plantsCover seedbed with mesh to prevent vectorIsolate new crop form contaminated cropSelect planting dates to avoid high population of vectorsDense plantings compensate for diseased plantsUse barrier crops to minimize virus spreadAvoid overuse of insecticides that are not recommended to control the situation since they destroy natural enemies of pestsAvoid higher nitrogen applicationSow healthy seed and seedlingsUse yellow polythene smeared with grease to trap pest.	Horticultural oil. Control whiteflies for TYLCV (see whiteflies).
Pepper Veinal Mottle Virus (Virus de la marbrure nervaire) (PVMV)	Mottling on leaves and chlorotic vein branding and spreading. Distortion and stricture of leaves. Diminution of the number of fruits and distortion.	-Resistant varietiesUse insect-proof net to protect nurseryWeed the plot and remove contaminated plantsAvoid planting peppers close to established tomato and pepper fieldsSelect planting dates to avoid high population of vectorsDense plantings compensate for diseased plants.	

Cucumber Mosaic Virus (Virus de la Mosaïque du Concombre) (CMV)	Leaves have mosaic aspect light to dark green. Also fraying and stricture of leaves. Flowers can fall and fruits be wrinkled and bumpy, and sometimes have yellow to black rings.	-Use barrier crops to minimize virus spreadAvoid overuse of insecticides that are not recommended to control the situation since they destroy natural enemies of pestsAvoid higher nitrogen applicationSow healthy seed and seedlingsUse yellow polythene smeared with grease to trap pestProtect nursery with an insect-proof netWeed the plot and contaminated plantsResistant variety.	
Tobacco Mosaic Virus (Virus de la Mosaïque du Tabac) (TMV)	Mosaic, mottled, bended and frayed leaves. Greenish rings and necrotic areas on fruits.	-Use healthy seedsGrow resistant varietiesCrop rotation of 2 years without solanaceae or cucurbitsWeed the plot and eliminate contaminated plantsDo not touch healthy plants after touching contaminated plants and disinfect tools.	

Nematodes

Root knot nematode Meloidogyne spp.

Please see the groundnut section for information on this pest.

Pepper				
Nematode	Damage	Available Control Measures	Pesticides	
Root knot nematode	Plants wilt, leaves become	-Weed management.	Spirotetramat.	
(Nématode à galles)	yellow and appearance of root	-Crop rotation and intercropping.	Spray into roots.	
	galls/knots of different sizes	-Plant trap-plant like groundnut before crop.		
	and infected roots also	-Mix cropping or cover cropping with non-host		
	become enlarged and	crops.		
	distorted.	-Field solarization (heat treatment).		
		-Flood the plot.		
		-Use manure in nursery.		
		-Avoid growing on an infected plot.		
		-Dig up and let dry the attacked plants.		

EGGPLANT

The eggplant originally came from India and was further spread to the Mediterranean and Africa. African eggplants are usually of the smaller and bitterer kind. They are usually yellow, and most commonly referred to as *garden eggs*. Eggplant is used widely in West Africa. It is chopped, cooked and mixed into a variety of vegetable dishes, meat-/fish-dishes and sauces. It is mostly grown in small scale compound gardens. The young and almost mature fruits are used as a good source of vitamin A and C, potassium phosphorous and calcium.

They may be roasted, fried, stuffed, cooked as curry or pickled. Cooking for prolonged periods will destroy most of the vitamins.

Insect pests/mites

Shoot borer (Chenille des boutons floraux)

See false codling moth under peppers

Cutworms Agrotis ypsilon, Spodoptera spp.

Cutworms attack eggplants and many other plants at night. They cut seedlings and usually drag them down into the soil leaving the clean-cut stem. They cannot cut older plants so they are only a problem in early crop growth.

White fly Bemisia tabaci

See tomato section for information on disease and preventative measures.

Cotton aphid Aphis gossypii

See cow pea section for information on disease and preventative measures.

Leafhoppers Empoasca sp.

See cow pea section for information on disease and preventative measures.

Leaf caterpillar Selepa docilis

This is a brown moth with white hind wings. The larvae are covered with long gray hairs and are pale green in color with pale yellow stripes on the back and a small black spot on the side. Usually the larvae feed in small groups to defoliate the plants close to where the eggs were laid. Eggs are laid singly near the leaf edge. Pupation occurs on cocoons on the leaves. Many generations are produced per year. Larvae feed voraciously and skeletonize the leaves leaving only the larger veins.

African bollworm Helicoverpa armigera

See tomato section for information on disease and preventative measures (tomato fruitworm)

Cotton leaf worm Spodoptera littoralis

See armyworm in cowpea section for information on diseases and preventative measures.

Spider mite Tetranychus (Aculops lycopersia)

Spider mites may become serious pests of eggplant during the dry season.

Leaf miner *Liriomyza trifolii*

Please see tomato section for general information on this pest.

Broad mite Polyphagotarsonemus (= Hemitarsonemus) latus

Please see the Peppers section for general information on this pest.

Thrips Frankliniella sp., Sericothrips sp

Please see the Groundnuts section for general information on this pest.

Egglplant				
Insect	Damage	Available Control Methods	Pesticides	
pests/Mites				
Shoot borer	Translucent black head	-Regularly check buds before flowering.	Tebufenozide.	
(Chenille des	caterpillar that then	-Pheramone traps.		
boutons floraux)	becomes red. Holes are			

	seen on bud. Stops fruit development.	-Use plastic as a source of mulching in eggplant to prevent the fully grown larvae to pupateRemove and destroy the affected tender shoots, fallen fruits, and fruits with bore holesReducing the use of insecticides in order to permit the natural enemies to proliferateAvoid continuous cropping of eggplant cropAvoid using alternate host in crop rotation.	Chilli and garlic extract. Neem seed extract before flowering to control egg laying.
Cutworms (Vers gris)	They reduce plant stand and weaken plants by cutting holes in the leaves or severing the base of the plant.	-Eliminate weeds early, at least 2 weeks before transplantingPlow and harrow the field prior to transplanting to expose cutworms to natural enemies, such as birds, and desiccation. It also helps destroy plant residue that could harbor cutwormsDig near damaged seedlings to remove cutworms The parasitic wasp, Cotesia (Apanteles) ruficrus, has been used in biological control.	Nuclear polyhedrosis virus. Chilli and garlic extract. Neem seed and neem leaf extracts 3 times at weekly intervals. Soil drench spinosad, indoxocarb, or imidacloprid (only in locations with most damage).
Whitefly (Mouche blanche)	Leaves dry out and roll up. Reduced growth. Presence of black wax on attacked organs.	-Same as leafminerInstall insect-proof nets to protect the nurseryWater regularly on the foliageDestroy plants residues after the last harvest.	Spray neem seed extract, laundry bar soap, or Horticultural oil. If greater control is warranted spray spinosad, pymetrozine, horticultural oil
Cotton aphid (Puceron du coton)	Suck sap under leaves, stems and young buds. Produce honeydew that favors black fungus infestation of leaves. Leaves become yellow, distorted and dry. Presence of black wax on attacked organs.	-Put insect-proof nets to protect the nurseryWater regularly on the foliage.	or imidacloprid. Horticultural oil.
Leafhopper (Cicadelle)	It sucks the sap from the under side of the leaves. The injured leaf margins	IntercroppingObserve plants at crop beginning to identify symptoms as soon as possible.	Laundry bar soap or neem seed extract.

	turn yellow then brown	-Plant resistant variety.	
	and tend to curve	-Plant resistant variety. -Balanced plant nutrition.	Apply incocticide
	downward.	-Avoid to grow near malvaceae or solanaceae.	Apply insecticide
		-Avoid to grow fiedr fildivacede of soldflacede.	when first
	Leaves dry and can fall		damage
	down.		appears,
			particularly at
			seedling stage.
			No treatment is
			necessary after
			fruiting.
Leaf caterpillar	The larvae feed on the	-Hand remove egg masses.	Bacillus
(Chenille de la	leaves removing all but	-Remove weeds early in the crop.	thuringiensis,
feuille)	the main veins.	Remove weeds early in the crop.	neem seed
reunie)	the main venis.		extract, or
			chloranthranilipr ole EC.
African bollworm	Elongated holes on	-Observe plants at the beginning of growing.	Tebufenozide or
Afficali bollworth	leaves.	-Use insect-proof nets for nursery.	nuclear
	leaves.	· · · · · · · · · · · · · · · · · · ·	
		-Pick caterpillars by hand.	polyhedrosis
		-Sprinkler irrigation.	virus.
Cotton leaf	Most defoliation occurs	-Hand remove egg masses.	Bacillus
worm	on young plants which	-Remove weeds early in the crop.	thuringiensis,
(Noctuelles du	can be killed.		neem seed
cotonnier)			extract, fire ash,
			chili peppers, or
			chloranthranilipr
			ole EC.
			Lambda
			cyhalothrin,
			deltamethrin, or
			dimethoate.
Spider mite	Attacked leaves show a	-Install windbreaks around the field.	Sulfur WP and
	stippled appearance	-Leave a distance between the crop and the field	canola oil.
	(white specks), and their	borders.	
	surface becomes	-Favor sprinkling irrigation on leaves.	Horticultural oil.
	covered with a fine silk	-Weed the field.	
	web. Continuous	-Remove crop residues after harvest 2-3 times at 10-day	
	infestation causes the	intervals.	
	leaves to dry-up. The	-Conserve natural enemies (like predatory mites and	
	plants are stunted and	anthocorid bugs) by avoiding use of broad-spectrum	
	yields reduced.	pesticides.	
	Brown areas on stems.	-Provide good growing conditions for plants as healthy	
	Fruits with crackled	plants are more likely to withstand mite attack.	
	aspect.	-Adequate irrigation.	
		-Apply mulch and incorporate organic matter into the	
		soil to improve the water holding capacity and reduce	
1 6 1	NAC	evaporation.	Code
Leaf miner	Mines and white marks	-Install insect-proof nets to protect the nursery.	Spinosad,
	on the leaf surface.		indoxacarb,

(Mouche		-Spray repellent substances of garlic, onion, or red	bacillus
mineuse des		pepper.	thuringiensis, or
feuilles)		-Perform a shallow ploughing.	neem.
Liriomyza spp.		-Remove crop residues.	
Broad mite	Sucks the sap of leaves	-Resistant variety.	Neem seed cake,
(Tarsonème)	that become dwarfed,	-Favor sprinkling irrigation on leaves.	sulfur, or
	batches and bended.	-Leave a distance between the crop and the field	horticultural oil.
	Veins are big and	borders.	
	sinuous. Fruits get	-Remove crop residues after harvest.	
	stripes, buds fall down.		
Thrips	End of leaves dry, and	-Water plants regularly.	Neem seed
(Thrips)	leaves get small silvery	-Mulch the soil with plant residues.	extract,
	stains and curl.	-Plough the land.	spinosad,
	Distorsion as and	-Eliminate weeds.	soap solution, or
	necrosis of young	-Use traps.	horticultural oil.
	flowers and fruits.		

Diseases

Bacterial wilt Ralstonia (= Pseudomonas) solanacearum

See tomato section for information on this pest.

Fusarium wilt Fusarium oxysporum f.sp. melongenae

See okra section for control.

Bacterial spot Xanthomonas campestris pv. vesicatoria

Please see tomato section on this pest.

Cercospora leaf spot Cercospora abelmoschi

Please see okra section on this pest.

Early blight *Alternaria solani*

See tomato section for information on this pest.

Late blight Phytophthora infestans

See tomato section for control.

Powdery mildew Leveillula (= Oidiopsis) taurica

The fungus grows within the leaf contrary to other powdery mildew fungi that are grow on surface of the leaves. It has a wide host range. It is not seed-borne but it survives on herbaceous weeds and other susceptible hosts. Temperatures slightly above 20° C, dry conditions and fairly high relative humidity favor disease infection. However, fungal dispersal takes place mainly at low humidity.

Anthracnose Colletotrichum melongenae

The fungus usually attacks fruits on plants that are weakened or over-ripe. Infection is favored by relative humidity close to 100% and temperatures between 20 and 30° C.

Cucumber Mosaic Virus (Virus de la Mosaïque du Concombre) (CMV)

See cucurbits section for general information on this pest.

Pepper Veinal Mottle Virus (PVMV)

See peppers section for general information on this pest.

Damping off fungi Exserohilum turcicum [Setosphaeria turcica], Pythium spp. Rhizoctonia spp. See millet and Sorghum section for information on this pest.

Phytophthora fruit rot Phythophthora parasitica

See tomato section for control and hibiscus section for more information.

Eggplant Disease	Damage	Available Control Methods	Pesticides
	Damage		Pesticides
Bacterial wilt	Plant wilts and internal part of the	-Certified seeds or sterilize seed.	
(Flétrissement	stem gets brown.	-Crop rotation avoiding successive solanaceae	
bactérien)		crops.	
		-Resistant varieties.	
		-Avoid working on infested soil.	
		-Avoid irrigating with water passing through contaminated fields.	
		-Remove infested plants and residues.	
Fusarium wilt	Branches or whole plant wilts from	-Good soil drainageSterilize nursery bed soil by burning.	No funcicidos
(Flétrissement	Branches or whole plant wilts from the bottom to the top. Yellowing	-Increase soil pH to 6.5 to 7.0 with lime or	No fungicides
fusarien)	on one side of the plant which	fertilizer.	are very effective.
rusarieri)	withers and dies. Browning of the	-Crop rotation of 3/4 years without cucurbits if	enective.
	inside part of the stem. Roots	there has been an infestation.	Neem cake
	stunt.	-Remove crop debris after harvesting.	application.
Bacterial spot	Attack leaves, stems and fruits and	-Crop rotation: if infestation, no solanaceae	аррисаціон.
(Galle	cause little dark spots with angular	during 2/3 years.	
bactérienne)	shape that coalesce and cause	-Remove crop residues.	
bacterierine	yellowing, decline and leaf drop.	-Avoid overhead watering.	
	Elongated spots can also appear on	-Use resistant varieties.	
	stems. Brown spots can also	Ose resistant varieties.	
	appear on fruits.		
Cercospora leaf	Dark green or brown round spots	- Use healthy seeds.	Mancozeb.
spot	surrounded by a yellow ring on	-Remove crop residues and infested plants.	
(Cercosporiose)	young plants, but turn white on	-Avoid overhead watering and otherwise water	
(30.000)	older crop. Leaves turn yellow then	early in the morning.	
	wilt and fall. Elongated spots on	-Crop rotation with, for example, sorghum, maize,	
	stems.	or fodder plants.	
Early blight	First black spots with yellow	-Resistant variety.	Mancozeb.
(Alternariose)	borders appear on leaves, then	- Remove crop debris.	
	larger brown spots. On fruit spots	-Disinfect seeds.	Treat once a
	start at the attachment point.	-Crop rotation of 3/4 years.	week when
		-Avoid watering the foliage at the end of the day	detected
		or at night.	
Late blight	Irregular oily green-black spots that	-Remove crop debris and burn infested plants.	Fluopicolide,
(Mildiou)	later turn brown on leaves and	-Use resistant variety.	fosetyl-
	stems. Fruits get dark, harder with	-Avoid overhead watering.	aluminium, or
	a lumpy shape.		mancozeb.
			Apply sulfur
			treatment
			before first

			rain and
Powdery mildew (Oïdium ou Blanc)	yellowish spots on the leaves. On the lower surface of affected leaves the spots are covered by a whitish growth (spores). Affected leaves eventually dry up but do not fall off.	-Remove weeds and plant residuesPractice overhead wateringUse of resistant varieties, if available.	every 5 days. Mancozeb or sulfur. Seed treatment: thiamethoxa m, mefenoxam, and difenoco nazole. Seed treatment: 5% sesame oil, fish oil, or neem oil.
Anthracnose (Pourriture rouge)	Disease infects overripe fruit. Causes round, concave, sunken spots with orange/light brown concentric pattern at their center. When weather is moist, the spots get tan-colored from growth of fungal spores. There may be several spots on infected fruit and they may join up and cover the whole fruit. Severely affected fruits drop. Eventually, affected fruits dry and become black. Most often, soft-rot bacteria invade affected fruits and cause a soft watery decay	-Use healthy seeds (certified, disease-free)Use resistant varieties, if availableCrop rotation of 3 years without solanaceaeAvoid overhead wateringHarvest fruits as soon as ripeRemove attacked plants and destroy infected crop residues.	Mancozeb.
Cucumber Mosaic Virus (Virus de la Mosaïque du Concombre) (CMV)	Leaves have mosaic aspect light to dark green. Also fraying and stricture of leaves. Flowers can fall and fruits be wrinkled and bumpy, and sometimes have yellow to black rings.	-Protect nursery with an insect-proof netWeed the plot and remove contaminated plants.	
Tobacco Mosaic Virus (Virus de la Mosaïque du Tabac) (TMV)	Mosaic, mottled, bended and frayed leaves. Greenish rings and necrotic areas on fruits.	-Use healthy seedsGrow resistant varietiesCrop rotation of 2 years without solanaceae or cucurbitsWeed the plot and eliminate contaminated plantsDo not touch healthy plants after touching contaminated plants and disinfect tools.	
Pepper Veinal Mottle Virus (Virus de la	Mottling on leaves and chlorotic vein branding and spreading. Distortion and stricture of leaves.	-Resistant varietyUse insect-proof net to protect nurseryWeed the plot and remove contaminated plants.	

marbrure nervaire) (PVMV)	Diminution of the number of fruits and distortion.	-Avoid planting peppers close to established tomato and pepper fields.	
Damping off fungi (Fonte des semis)	Causes death and wilting of the young plants. Surviving plants may have reduced growth and yellowing leaves. A fine white powdery (the fungus) can be seen at the soil surface.	-Crop rotationAvoid wet soilsFavor good drainage and good soil aerationUse treated seedsWater only when soil is dry.	Fluopicolide. Seed treatment: mancozeb or thiram. Seed treatment: thiamethoxa m, mefenoxam, and difenoco nazole. Application of neem cake.
Phythophthora fruit rot		-Grafting onto resistant root stockAmend soil with compostDigging drainage ditchesAvoid over-wateringPlace drip irrigation spigots away from tree trunks.	Azoxystrobi as a soil drench. Fluopicolide or fosetyl- aluminium.

Nematodes

Root knot nematode *Meloidogyne spp.*Eggplant is highly susceptible to root-knot nematodes, especially on sandy soils.

Eggplant			
Nematode	Damage	Available Control Methods	Approved
			pesticides
Root knot	Plants wilt or stunt,	- Use resistant varieties, if available.	Spirotetramat.
nematode	leaves become yellow	-Weed management.	Spray into
(Nématode à	and appearance of	-Crop rotation and intercropping.	roots.
galles)	root galls/knots of	-Plant trap-plant like groundnut before crop.	
Sting	different sizes and	-Mix cropping or cover cropping with non-	
nematode	infected roots also	host crops.	
	become enlarged and	-Field solarization (heat treatment).	
	distorted.	-Flood the plot.	
		-Use manure in nursery.	
		-Avoid growing on an infected plot.	
		-Dig up and let dry any attacked plants.	
		-Maintain high levels of compost.	

IRISH POTATO

Potato originated in the highlands of South America, where it has been consumed for more than 8000 years. Spanish explorers brought the plant to Europe in the late 16th century as a botanical curiosity. By the 19th century it had spread throughout the continent, and in the 1880s, British farmers introduced it to East Africa. The potato has grown in importance in Africa both as a staple food and as a source of farmer incomes over the past 30 years. Potato requires well-distributed rainfall of 500 to 750 mm in a growing period of 3 to 4.5 months, but in Niger it is irrigated. Potato is tolerant of a rather wide variety of soils, except heavy, waterlogged clays. Good drainage is of great importance. Deep soils with good water retention and aeration give best growth and yields. On the contrary, impermeable layers in the soil limit rooting depth and the amount of available water, reducing yields. The most suitable soil pH is between 4.8 and 6; at higher pH, tubers are liable to suffer from scab disease. The whole of Africa produces only 4% of the world production of potatoes. In Africa, roughly 40% of all root and tuber crops are produced by Nigeria next to Niger. According to the FAO the average yield in Niger is 18 t/ha compared to the top by New Zealand of 44 t/ha and Nigeria at 4 t/ha. Area planted to potatoes has been rapidly increasing over the past five years. In Niger potatoes are often boiled and eaten with meat. Only some is exported however as there is a local demand in Niger.

Insect pests/mites

Mole cricket Gryllotalpa africana

Mole crickets adults are 22-28 mm long, brown in color with have short wings folded over their abdomens. They are soil pests, active during the rainy season. They make tunnels (of 10-15cm depth) to find roots and tubers on which to feed, and wherein females lay eggs. They dig their tunnels close to the ground surface when it is warm, and come out of the tunnels at night to feed on leaves and stems. Feeding on tubers allows secondary infection to occur, which further degrades tubers. Mole crickets are particularly damaging to recently planted tubers where their feeding can kill the potato plant.

Termites Odontotermes, Microtermes

Termites are social insects living in large colonies consisting of workers, soldiers, and reproductive forms. Some elaborate nests on moist dead tree stumps, while others build subterranean nests, which in many cases have mounds that may reach 2m in height. They forage away from the nest protected through underground tunnels or under soil-covered tunnels. They feed on dead plant material, such as wood, leaf litter, roots, dead herbs and grasses, dung, and humus. Some are able to digest cellulose (wood) with the assistance of symbiotic (mutually beneficial) bacteria present in their gut. Other termites use the cellulose to cultivate fungi that are then eaten.

Cutworms Agrotis ypsilon

Cutworms are caterpillars of some moths. They are also serious pests of newly sprouted potato plants, and can leave great empty patches in a potato field. Young caterpillars are pale, yellowish-green with a blackish head. Older caterpillars have a plump body; their color varies from grey, dark green to brown or black with shiny, greasy-looking skin. Fully-grown caterpillars are 4 to 5 cm long. They are nocturnal and hide in the soil or under stones and plant debris during the day. At night they move up to the soil surface to feed. Caterpillars construct burrows or tunnels in the soil about 2.5 to 5 cm deep near the host plant. They pupate in an earthen cell in the soil. The nature of the soil has a large influence on the rate of infestation. Cutworms tend to be more frequent in soil with large amounts of decaying organic material or where organic manure has been applied. Damage is worse where cutworms are present in large number before planting. Cutworms often reoccur in the same field, coming with crop residues and dense stands of weeds. Damage to underground tubers may be difficult to

recognize before harvest. Damage is far more severe under very dry conditions and occurs deeper underground in more moist soil.

Damage is monitored by counting damaged and freshly cut leaves, freshly cut young plants, and holes in leaves and in stems. Monitoring should be done at dawn. Control before thinning is advisable where high numbers of cutworms are present. Control is normally not needed when plants are about 25 to 30 cm tall, but heavy attacks can even kill taller plants.

Aphids Myzus persicae, Macrosiphum euphorbiae, Aulacorthum solani, Aphis gossypii

Many aphid species attack potatoes. The most important are the green peach aphid *Myzus persicae*, the potato aphids *Macrosiphum euphorbiae*, *Aulacorthum solani*, and the cotton aphid *Aphis gossypii*. These aphids are mainly found on young shoots and on the underside of leaves. Potato aphids can attack potato sprouts in stores. Direct damage caused by aphids sucking sap from the plant is usually of little importance. Aphids are important pests as vectors of potato viruses. Seed potatoes are particularly susceptible to this virus and even low aphid populations can be very damaging.

The African armyworm Spodoptera exempta

The armyworm is a migratory moth. Its larvae (caterpillars) are important pests of pastures and cereal crops, predominantly in Africa, south of the Sahara. Normally, only small numbers of this pest occur, however, periodically the populations increase dramatically. Outbreaks follow the onset of wet seasons when dry grasslands produce new growth and cereal crops are planted. The severity and extent of outbreaks are increased by extended drought followed by early season rainstorms, which concentrate egg-laying moths and provide flushes of new grass as food for newly hatched caterpillars, and dry and sunny periods during the caterpillar development, which promote survival and rapid development. Caterpillars are major pests in outbreak years, causing significant losses on a local, national and regional scale. During outbreaks, caterpillars occur in such high numbers that they have to travel in masses from one field to another (hence the name "armyworm") in search of food to complete their development, devastating crops as they move. In recent decades, the frequency of reports from West Africa has increased, possibly due to the extension of suitable grassland habitats following forest and bush clearance for agriculture.

The economic importance of the African armyworm is due to its short life cycle, high reproductive capacity, and mobility by migration. Moreover, there is little time to react as infestations frequently go unnoticed, since young caterpillars are difficult to detect. When caterpillars become conspicuous (at the fourth stage), they cause a lot of damage in a very short time. The degree of damage to crops depends on stage of development of the crop, prevailing weather conditions, the density of caterpillars present, and affected area. Armyworms feed at night and hide under debris during the day. Solitary forms are usually sparsely distributed and difficult to find. Older caterpillars drop to the ground if disturbed. With large populations the ground may be literally covered with the gregarious band of caterpillars.

If conditions are known to be favorable to the pest, a close watch daily should be kept on grassland and young cereal crops. The earlier the infestation is noticed, the more effectively can control methods be carried out. Monitor in late evening or early morning, when they are active. Examine 100 plants at random by examining 20 plants from five locations. Look in field margins, low areas where plants have lodged, beneath plant debris around the base of plants, on the ground, and underneath the plant leaves. To avoid yield losses of over 15%, action thresholds should be taken as 200 second (L2), 80 third (L3), or 20 fourth (L4) stage caterpillars per 100 plants.

Potato tuber moth Phthorimaea operculella

Potato tuber moth is a widely distributed, the most serious pest of potatoes in the region. It attacks mainly in warmer climates, both in fields and stores. The moth larvae also feed on other solanaceous crops such as tomato, pepper, and eggplant. While damage to leaves does not usually become economical while that to the tubers can be devastating. In stores it prefers very warm temperatures so, if the tubers are in refrigeration there is no significant loss. The moth is small (up to 12mm long), brownish grey in color with narrow fringed wings. They are active mainly at dusk, but occasionally they can be seen flying within potato plants. Female moths lay eggs singly or in small batches on sheltered places of the foliage (leaf and stems) and near the eye buds on exposed tubers through cracks in the soil or in the store. When eggs are laid on tubers, caterpillars begin feeding on the tubers immediately upon hatching. Larvae often move from foliage to feed on exposed tubers, or gain access to tubers by crawling down cracks in the soil. They do not bore into the tubers from the stems. Larvae that have bored into tubers move away in order to pupate usually in the soil surface or on crop debris in the field. They pupate in a silken cocoon covered with soil particles and debris among dead potato leaves, soil litter, eyes of tubers, and storage walls and floors. Caterpillars burrowing in the tubers cause major damage by making long irregular black tunnels filled with excreta, where disease-causing microorganisms grow. These tunnels provide an entry point for various plant pathogens and make the potatoes unfit for human consumption. The pest is transferred with the harvested tubers to the potato store, where it can reproduce and infest other tubers. This may lead to total destruction of the stored crop.

Irish potato	Irish potato			
Insect pests/Mites	Damage	Available Control Measures	Pesticides	
Mole cricket (Taupe- grillon)	Tunnels into tubers, cuts vines. Nymphs feed on roots and tubers and cut plants and vines that they pull into their tunnels to feed.		Treat the soil with diazinon granules. Imidaclorprid soil drench. Neem cake application.	
Termites (Termites)	Feed on sown-seed and the germinating seedling as well as roots of older seedlings. Some termites eat into the taproots of young plants immediately below the soil surface, destroying the central root portions. Movement of nutrients and water through the vascular system may be disrupted by tunneling. Damaged plants wilt and may die within a few days particularly under drought conditions	-Deep plowingOverseedingCrop rotationMixed cropping systemsPromote conditions for healthy plant growthAvoid unnecessary injury to the plantsRemove plant residues and other debris, especially moist and decaying woodsAvoid bare, dry disturbed, organic-deficient, residue-free soilInspect plants, especially the pruned fruit trees, for termite attack, early in the morning or late in the afternoon.	Imidacloprid seed treatment or soil drench with a sprayable formulation. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole. Neem seed extracts.	

Cutworms (Vers gris)	Newly hatched caterpillars feed on the leaves and later on the	-Remove affected plants or parts of plants, and kill the termites; normally found inside the hollowed partsHarvest at the right time, as termites often attack maize, sorghum, and millet left in the field after maturityAvoid leaving the crop in the field after harvestDeep tillagePlanting timePlowing.	Spinosad, chloranthraniliprole, Bacillus thuringiensis,
	stems. Older caterpillars feed at the base of plants or on roots or stems underground. Feeding on tubers and roots results in a variety of holes, ranging from small and superficial to very large deep ones.	-Destroy weeds 10 to 14 days before planting. -Delaying transplanting slightly until the stems are too wide for the cutworm to bite and/or too hard for it to cut may reduce cutworm damage. -Plant as deeply as possible (10cm deep) and ridge at least three times during the growing season. -Increasing the sowing depth from 3cm to 8cm. -At the beginning of infestation, handpick caterpillars at night by torch or very early morning before they return into the soil. -Flooding of the field for a few days before sowing or transplanting. -Check fields for cutworm before sowing or transplanting. -Use pheromone traps to time the presence of the pest.	neem seed extract, or nuclear polyhedrosis virus.
Aphids (Pucerons)	Leaves are yellow, curl, dry and distorted. Plants are small. Presence of black wax on attacked organs.	-Install insect-proof nets to protect the nurseryWater regularly on the foliageEarly plantingGood nutrition for the plant.	Neem seed extract. Chili extact. Soap.
		-Conserve natural enemies by using selective insecticidesKeep seed production areas separated from commercial potato productionRemove yellow flowering weeds and any other host plants within and around the field.	Horticultural oil.

		-Protect potato tubers during storage by preventing access of aphids. -Use yellow sticky traps as a monitoring method. Populations can be reduced by farmers setting out 5-10 sticky traps in the edges of their fields. Face the traps into the prevailing winds. -Check the field regularly.	
African armyworm (Légionnaire)	Gross feeding damage to foliage, growing points and young stems. 'Window' effect on leaves; leaves may dry up and assume a scorched appearance. Ragged appearance on older leaves. Severe infestation results in total defoliation or destruction of the plant to ground level.	-Hand remove egg massesRemove weeds early in the cropHandpicking the caterpillarsRegular monitoring is vital.	Bacillus thuringiensis, neem seed extract, chloranthraniliprole EC, fire ash, chili peppers, tebufenozide, or nuclear polyhedrosis virus. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: lambda cyhalothrin, deltamethrin.
Potato tuber moth (Teigne de la pomme de terre)	Larvae tunnel into stored potato seed. They feed as leaf miners between the upper and the lower epidermis and bore into the petiole, or a young shoot or main leaf vein and later into the tuber. Burrowing in the tubers.	-Store tubers in 20cm deep dry soil after drying in the sunCrop rotationRemoval of volunteer sprouts from fieldUse of healthy, clean seedAvoid planting in hard soilPlant as deeply as possible (10cm deep)Ridge at least three times during the growing seasonEnsure compact hillingProvide enough water to prevent soil cracksMulch the plants with strawHarvest the crop immediately as it maturesAt harvesting select and store only uninfested tubers, chose a cool place, keep storage cleanBag and remove all harvested tubers before late afternoon every day.	In the field: chloranthraniliprole, spinetoram, or indoxacarb. Stored potatoes: Bacillus thuringiensis mixed with talcum or fine sand, neem seed extract, or wood ash.

	-Destroy all infested potatoes	
	immediately and remove all plant	
	residues.	
	-Conserve natural enemies.	
	-In the field and storage, monitor	
	with pheromone traps.	

Diseases

Bacterial wilt Ralstonia (=Pseudomonas) solanacearum

Bacterial wilt can be very in the warmer extremes of the potato's range. This disease causes rapid wilting and death of the entire plant without any yellowing or spotting of leaves. All branches wilt at about the same time. The pathogen is transmitted through tuber seed into the soil. Also, infested soil can be important source of disease infection.

Stem rot Sclerotium rolfsii

S. rolfsii attacks many field and vegetable crops in warm regions. Losses typically occur at the end of the season. The fungus persists in soil between crops. Tubers are typically infected by way of underground stems. The fungus quickly grows over the tuber surface and invades, resulting in a moist cheesy decay. The fungus can invade dead vines as well as living ones. Extensive tuber losses can be initiated within a few days of harvest if the fungus is present, and rot can continue in transit. Hot temperatures 30-35°C and moist soil surfaces favor germination and infection by dormant spores.

Late blight Phytophthora infestans

This disease is favored by cool, cloudy, wet conditions. Symptoms of late blight are irregular, greenish-black, water soaked patches, which appear on the leaves. The spots soon turn brown and many of the affected leaves wither, yet frequently remain attached to the stem.

Early blight *Alternaria solani*

On the potato tuber early blight results in surface lesions that appear a little darker than adjacent healthy skin. Lesions are usually slightly sunken, circular or irregular. There is usually a well-defined and sometimes slightly raised margin between healthy and diseased tissue. Internally, the tissue shows a brown to black corky, dry rot, usually not more than 6 mm. Deep cracks may form in older lesions. Early blight thrives best under warm wet conditions.

Common scab disease Streptomyces scabies

Common scab of potato is caused by a filamentous bacterium in the genus *Streptomyces*. The bacterium is a saprophyte that can survive for long periods on decaying soil organic matter in the absence of hosts. Tubers are susceptible as soon as they are formed and in most cases infections occur while they are still on the ground. Dry soil conditions during this period reduce competition and can serve to encourage infection by the pathogens. A mature tuber with healthy skin set is no longer susceptible to new infection by the pathogen. Scab symptoms are most notable at harvest or later in the season. The pathogen enters through wounds, pores in the epidermis, or directly through the skin of young developing tubers and stimulates the growth of corky tissue. Lesions expand as the tubers expand. The pathogen produces spores in the lesions, which may be so numerous as to involve the entire surface of affected tubers. Such lesions spoil the appearance of the tubers

and cause waste in peeling and reduction in grade. Neither the pathogens nor the disease develop on tubers in storage.

Bacterial soft rot Erwinia carotovora

Infected vines release bacteria to the soil and the bacteria can move to new tubers through soil water. The bacterium enters through wounds and causes extensive rotting of potatoes due to degradation of tuber cell walls. Severely affected plants die, and tubers from diseased plants may show a black soft rot during storage. The pathogen is carried within diseased potato tubers or other plant debris, but it is usually dormant and does not cause disease symptoms unless environmental conditions are favorable. In storage, soft rot only spreads easily but must enter through wounds either caused mechanically or by fungi such as leak and pink rot. Wet tubers having free water on the surface are very prone to soft rot infection.

Viruses Potato Leaf Roll Virus (PLRV), Potato X Potexvirus (PVX), Potato Virus Y Potyvirus (PVY)

Aphids transmit these viruses. Under field conditions, there is often a composite infection with the three viruses (PLRV; PVX; PVY) and it becomes very difficult to distinguish the three on the basis of symptoms. PLRV also infects other solanaceous crops and weeds. Virus spread early in the season is more serious than later on, as young plants are generally more susceptible. Moreover, plants that are infected early become more efficient sources for further virus spread than plants infected later in the season.

Irish Potato			
Disease	Damage	Available Control Methods	Pesticides
Bacterial wilt (Flétrissement bactérien)	Plant wilts and internal part of the stem gets brown.	-Certified seeds or sterilize seedCrop rotation avoiding successive solanaceae crops for 4 yearsResistant varietiesAvoid working on infested soilAvoid irrigating with water passing through contaminated fieldsRemove infested plants and residuesGood soil drainage.	Neem cake application.
Stem rot (Pourritue de la tige)	Affected stems on plants with stem rot first show a moist decay at or slightly below the soil surface where infection is initiated. Stem lesions expand up and down the stem, and leads to wilting and yellowing of foliage.	-Relatively early plantingDo not store tubers in the ground unnecessarily before harvestRotate with crops that are less susceptible (such as non-fleshy, root, or tuber crops)Practice high nitrogen fertilityRestrict irrigation during rainy weather, and on cool, cloudy days, whenever possibleAvoid practices that promote long periods of leaf wetness or high relative humidity within the crop canopy.	Apply mancozeb if severe disease pressure. A single treatment at row closure is enough where spores are discharged over a short period.
Late blight (Mildiou)	Irregular oily green- black spots that later turn brown on leaves and stems. Fruits get	-Remove crop debris and burn infested plantsUse resistant varietyAvoid overhead watering.	Fluopicolide, fosetyl- aluminium, or mancozeb.

	dark, harder with a lumpy shape.	-Practice rotation with non-solanaceous cropsSelect only certified, disease-free seedPlant potatoes in well-drained soils.	Apply sulfur treatment before first rain and every 5 days.
Early blight (Alternariose)	First black spots with yellow borders appear on leaves, then larger brown spots. Spots are circular, up to 12 mm in diameter. On fruit spots start at the attachment point.	-Resistant variety Remove crop debrisUse disease-free certified seedsCrop rotation of 3/4 years with nonsolanaceous cropsAvoid watering the foliage at the end of the day or at nightWhen using one's own seeds, disinfect them with bleachPractice good field hygieneLay down a thick organic mulch to prevent soil splashing onto lower leaves.	Mancozeb, once a week after detected.
Common scab disease (Gale commune)	Corky tissue forms in harvested tubers. Initially, infections appear as small tan to reddish-brown spots on the tuber surface. Pitted scab can be as deep as ½ inch into the tuber. Infections can also occur on the stems, underground stems, or roots.	-Select healthy tubersResistant varietyAvoid wet manureCrop rotationIncrease soil acidity by using acidifying fertilizers (N source from ammonium sulfate, use gypsum rather than lime)Plant healthy certified seed with no scab lesionsDisinfect seed tubers from infected field through heat-treatment (10 minutes in water at 55 degrees Celsius).	Mancozeb for seed with scab contamination.
Bacterial soft rot (Pourriture molle bactérienne)	Tubers putrefy and are often reduced to a smelly pulp. Latent infection can lead to non-emergence of plants, chlorosis, wilting, desiccation of the tops of stems, and typical soft rot.	-Use clean seedAvoid wounding tubersAvoid wet soilSelection of resistant varieties where availableSanitize storage facility, eliminate condensation, and keep well ventilatedDo not wash tubers before storingAvoid excess wateringPractice field hygieneAvoid harvesting under wet conditionsHarvest mature tubers with set skin.	Chemical control not effective.
Viruses PLRV, PVX, PVY	PVX causes distinct leaf mottling and crinkling. PVY causes dwarfing of plants, with a rough, mosaic appearance to the leaves. Affected plants give a poor crop of	-Ensuring the use of virus-free seed tubersPlant resistant varieties where availableUproot infected plants. For maximum effectiveness remove the diseased plant, the three plants on each side of it in the same row, and the three closest plants in adjacent rows.	See aphid information.

small tubers. PLRV causes upward and inward rolling of leaflet margins and plants are dwarfed. Affected leaflets become thick and dry, and the lower leaves may become completely brown. Infected plants produce tubers smaller in size and numbers.	-Control insect vectors to reduce virus spread. -Do not overlap potato cropsPractice good field sanitationControl alternate weed hosts and volunteer potatoesHarvest seed potatoes no later than 8 to 10 days after a critical aphid build-up or increased virus infection rates are noted.
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Nematodes

Root knot nematodes Meloidogyne spp

Potatoes are very susceptible to root-knot which are likely to become established in potato crops grown in relatively warm areas. Attack reduces the quality, size and number of tubers. Infestations are difficult to detect in freshly harvested potato tubers. Symptoms may develop when tubers are stored. Infested potatoes can become more susceptible to bacterial wilt, and symptoms are more severe when plants are also infected with fungal pathogens. Nematodes are mainly spread in potato tubers and in infested soil. Egg masses may be transported into clean fields via soil adhering to farm machinery. Spread within fields occurs during cultivation and in water, during irrigation or natural drainage. Symptoms are most severe when crops are grown on sandy soils and warm climates above 25°C.

Irish Potato			
Nematode	Damage	Available Control Methods	Pesticides
Root knot nematode (Nématode à galles)	Plants wilt, leaves become yellow and appearance of root galls/knots (small, raised lumps near tuber eyes) of different sizes and infected roots also become enlarged and distorted. Skin with rough appearance. Tubers with blisters and swellings.	-Weed managementCrop rotation and intercroppingPlant trap-plant like groundnut before cropMix cropping or cover cropping with non-host cropsField solarization (heat treatment)Flood the plotUse manure in nurseryAvoid growing on an infected plotDig up and let dry any attacked plantsMake compost from animal manure and strawSterilize farm tools and machinery.	Spirotetramat. Spray into roots.

SWEET POTATO

Sweet potatoes are perennial vines, with one main season. They have their origin in tropical America and European traders brought the plant to Africa. It is widely grown mainly in subsistence farming and currently gaining popularity again along with other indigenous foods. Sweet potatoes can be boiled, roasted, fried, creamed or baked in their skins. They are easily combined with both sweet and savory dishes. The roots are eaten either boiled or roasted alone or with other foods such as milk, soups or meat. Roots are sometimes prepared in a porridge that might also include cowpea, lima bean, sesame, and/or millet. There has been some development in recent years of sweet potato snacks, such as chips sold in urban markets. Young leaves are used as vegetable and are high in protein (approximately 20% of dry weight), and are also a good source of bcarotene, thiamine (vitamin B1), riboflavin (B2), folic acid and ascorbic acid. The sweet potato vines are a useful and nutritious fodder crop, especially in the dry season. Nutritionists in the Sahel are promoting the use of yellow fleshed sweet potato varieties to combat wide spread vitamin A deficiency which decrease children's resistance to infectious diseases, contributing to infant mortality. Sweet potato is a sun-loving crop; however, it can tolerate a 30-50% reduction of full solar radiation. It grows best with a well-distributed annual rainfall of 600-1600 mm during the growing season. Dry weather favors the formation and development of storage roots. Sweet potato is relatively drought tolerant, however, it cannot withstand long periods of drought; the yield is considerably reduced if drought occurs about the time of planting or root initiation. Among the great diversity of cultivars grown, two types are commonly recognized. The staple types, grown throughout the tropics, are usually white, red or purple, although yellow-fleshed types are becoming popular in Africa. The orange-fleshed types, typically have a higher sugar and vitamin A and lower dry matter content.

Insect pests/mites

Sweet potato weevil Cylas puncticollis, C. brunneus

Sweet potato weevil is a major pest in Niger, causing losses up to eighty percent. Two species of weevils are involved: Cylas puncticollis (shiny black adult) and C. brunneus (several colors). It is not known if both species occur in Niger but they do in Nigeria. Sweet potato weevils fly infrequently and generally for only short distances ranging from 500 m (if there are host plants) to 1000 m. Most weevils (80-90%) can be found in the foliage from 10 cm above the ground level to 15 cm below in the ground. The sweet potato tuber is the preferred site for feeding and egg laying by adults, but in the beginning of the season, adult weevils live on leaves and stems. The adult feeds on the foliage and lays its eggs on the vines and leaves. The larvae are more damaging, feeding, boring and making tunnels into the stems and roots; it pupates inside the vines. As the plant gets older and starts to form storage roots, the weevils search for exposed roots. They cannot dig so their penetration into the soil is limited not allowing them to reach the roots that are buried. When an adult finds a root it punctures the surface as it feeds and also makes egg-laying punctures into which eggs are deposited. If roots with egg punctures are stored, they will serve as a source of infestation for the clean roots stored beside them. Once hatched the larvae bore into the roots. Damage to the vascular system can reduce the number and size of future storage roots. Even low levels of infestation can reduce root quality and marketable yield. Under dry conditions the weevil can become a more serious pest due to more cracks that give access to more roots. It is for this reason that during the dry season sweet potato roots cannot be stored in the ground for any significant period of time. Newly planted fields are also likely to be infested via planting material with eggs or larvae within the vines.

Monitor weekly weevil with pheromone traps but this technology is expensive so the cost should be borne by a group of farmers, as only one trap is enough. Damage by weevils can be recognized by the holes in the vines

or the tunnels in the tubers when you pull them up from the soil. Cut open tubers and look for tunneling and larvae.

Aphids Aphis gossypii, Mysus persicae

The cotton aphid and green peach aphid are the most common species of aphid on sweet potatoes. The adults and nymphs of these soft-bodied, pear-shaped insects are usually pale to dark green, sometimes yellow. Though winged forms develop periodically, most adults are wingless. All forms have a pair of small horns known as cornicles at the end of the abdomen. Congregating on lower leaf surfaces and terminal buds, aphids pierce plants with their needle-like mouths and extract sap. They may cause considerable damage during periods of water stress. Aphids tend to spread rapidly from field to field, transmitting a number of viral diseases. *Aphis gossypii* is a primary vector of sweet potato feathery mottle virus.

For monitoring aphid populations, see cowpea section on this pest where the threshold for preventing damage is 30% plants with aphids especially if aphid numbers are rapidly increasing.

Whiteflies Bemisia tabaci

Whiteflies are white insects that resemble tiny moths. They flutter when foliage is disturbed. Adults and immatures are often found feeding on the undersides of leaves. The excretion of honeydew and the subsequent development of sooty mold fungi also may reduce photosynthesis and other physiological functions of the plant. High numbers of whiteflies may affect plant development, particularly during period of water stress and drought. Furthermore, whiteflies are more damaging as vector of virus disease.

For monitoring whiteflies, see okra section where the threshold is 40% of leaves average at least 3 adults.

Sweet potato hornworm Agrius convolvuli

Sweet potato hornworm moths are variable in color, usually greenish or brownish. Fully-grown caterpillars are large (up to 10 cm long and 1.5 cm broad), with a conspicuous posterior horn. Adults are large grey hawk moths with black lines on the wings and broad incomplete pink bands on the abdomen and are active at night. The female lays small spherical greenish eggs singly on either surface of the leaves. Larvae feed on the foliage for about three weeks and then they burrow into the soil where they pupate. The pupal period lasts three weeks in the summer, then adults emerge to start a new generation. There are two to three generations per year, with the pupa being the over-wintering stage. When older caterpillars are present in large numbers they can defoliate a field overnight. Insect excreta can often be found near the infested plant part. Yield losses can occur if heavy defoliation takes place when the crop is young. But, if the young plants are healthy and growing well, they can recover. However, damage to the leaves may delay harvest, increasing the likelihood of attack by the sweet potato weevil.

Armyworms Spodoptera spp.

Several species of armyworms feed on sweet potato foliage, including the southern armyworm, yellow-striped armyworm and beet armyworm. They have a broad host range, feeding on many plants including several vegetable and field crops as well as weeds. They are daytime feeders but are sometimes difficult to find because they move to the base of the plant. Armyworm larvae are often found on foliage during the morning, evening or during the day if it is cloudy. Mature caterpillars measure up to 4 cm long and are generally black, heads faintly mottled with dark brown spots and with light yellow stripes at their backs. Eggs are placed in masses on the foliage by moths. Larvae, or caterpillars, emerge from eggs in four to six days and spend three to four weeks as larvae feeding on leaves, tender stems and branch tips. At the end of larval development, larvae drop to the ground, where they burrow into the soil and pupate. Adult moths emerge to start a new

generation. The life cycle from oviposition to adult emergence requires about five weeks in the summer. There are from three to five generations per year, depending on the species. As a general rule, defoliation must exceed 30 percent before yields are reduced. Defoliation late in the season will have less of an impact on yield than defoliation in the earlier stages. The natural enemies of these insects usually keep them from reaching levels that may cause yield loss. Because armyworms feed above ground on the plant foliage, they are fairly easy to control. Preventative and control measures are found on the table below.

Sweet Potato	Sweet Potato				
Insect pests/Mites	Damage	Available Control Measures	Pesticides		
Sweet potato weevils (Charançon de la patate douce)	Leaves are eaten. Larvae tunnel into the stems and roots. Infested tubers are often riddled with cavities or tunnels and eventually rot. Feeding in the vines causes thickening and malformation, often cracking of the tissue, discoloring it and causing wilting. Damage to the stems may cause serious mortality to seedlings.	-Site new plantings away from previous sweet potato fieldsSelect <30 cm lengths from the tips of vines as planting materialUse resistant varieties available (varieties that form roots deep in the soil or that have their roots mature quickly)Destroy crop residues after harvest by burning or feed to livestockRemove volunteer plants and alternate hostsCrop rotation on a cycle of 3 yearsUse un-infested planting material, especially vine tips, as weevils tend to lay eggs in more woody older parts of the vinesTimely planting to avoid the dry seasonPlant away from weevil infested fieldsUse a barrier crop, such as cassava or sorghum/millet, around the perimeter at least 3-5 m wideHill up the base of plants to cover the exposed rootsMulch the soil to prevent crackingHarvest earlyDo not store for a long timeDo not store roots that appear soft, smelly, or have external scarring or small, darkened holes.	Test chloranthraniliprole.		
Aphids (Pucerons)	Aphids attack terminal leaves, flower heads,	-Install insect-proof nets to protect the nursery.	Neem seed extract, soap sprays,		

	and stems of pods. Infested plants develop yellow foliage, may become dwarfed and malformed, and lose vigor. Stunted, wilted and discolored plants, leaves curl downward and pucker. Heavily infested plants turn brown and die from the top down. Presence of sticky honeydew and sometimes black sooty mold on plant foliage.	-Water regularly on the foliageEarly plantingGood nutrition for the plantConserve natural enemiesUse mulches.	imidacloprid, or horticultural oil.
Whitefly (Mouche blanche)	They remove plant sap, transmit virus diseases and cause black fungus appearance under leaves. Attacked leaves dry out, roll up, plants growth stops, and a black wax can be found on attacked organs. Chlorotic spots sometimes appear at the feeding sites on leaves, and heavy infestations cause leaf wilting.	-IntercroppingPut insect-proof nets to protect the nurseryYellow sticky traps reduce populationsWater regularly the foliageConserve natural enemies such as parasitic wasps and predators (predatory mites, ladybird beetles, and lacewings)After the last harvest, destroy all crop residues.	Spray neem seed extract, laundry bar soap, or horticultural oil. If greater control is warranted spray spinosad, pymetrozine, or imidacloprid.
Sweet potato hornworm (Sphinx de la patate douce)	Defoliation and irregular holes on leaves.	-Handpick caterpillars from leaves (especially in small areas)Turn the soil over between cropsMonitor populations with light traps.	If defoliation reaches 30% then spray an approved insecticide. Spinosad, tebufenozide, nuclear polyhedrosis virus, or Bacillus thuringiensis.
Armyworms (Légionnaires)	Young caterpillars scrape sweet potato leaves, while the older caterpillars feed producing large irregular holes and may leave only the veins.	-Hand remove egg massesRemove weeds early in the cropConserve natural enemies as predatory bugs, carabid beetles, spiders and waspsCollect and destroy leaves containing eggs and caterpillars.	Nuclear polyhedrosis virus (SpexNPV), tebufenozide, spinosad, or tebufenozide.

	-Hang light traps over basins of water in the field to trap the adults at night or pheromone traps.	
	or priorionic diapor	

Diseases

Sclerotial blight Sclerotium rolfsii

Although they occur at different stages of cultivation of sweet potato, sclerotial blight and circular spot are caused by the same soil borne fungus that also causes southern blight on many other crops. When the weather is humid, a coarse white mycelium of the fungus may grow out on the soil surface around the base of the plants and up the lower part of the sprouts. Later, small sclerotia (dormant stage of fungi) that resemble mustard seeds develop on the mycelia; these structures survive for years in the soil. Sclerotial blight is especially severe when there are 'seed' roots in the bed that are rotting because of some other disease, when there is dead leaf material on the surface such as when plastic covers have been left on too long, and when the plants are under stress from extremes of temperature or moisture.

Fusarium wilt Fusarium oxysporum f. sp. batatas

Death of the stem vascular bundles occurs with brown to purple discoloration; this may be accompanied by cracking of the stem. Diseased plants may manage to produce storage roots, but these usually have some discolored, infected vascular tissues. Rot may follow in storage or the disease may be transmitted to the next crop by infected cuttings. Dying vines often have pinkish fungal growth.

Sweet potato virus disease complex

This disease is caused by a combination of sweet potato feathery mottle virus (SPFMV) and sweet potato chlorotic stunt virus (SPCSV). SPFMV is a potyvirus transmitted by aphids (mainly *A. gossypii*) in a non-persistent manner whereas SPCSV is a crinivirus transmitted in a semi-persistent manner by the whitefly *Bemisia tabaci*.

For monitoring aphid populations, see cowpea section. Because the transmission of virus is the objective, the threshold should be 5% of plants with aphids.

Sweet Potato					
Disease	Damage	Available Control Measures	Pesticides		
Sclerotial blight	Leaves turn bronze then wilt. Circular spots develop on storage roots shortly before harvest. Lesions with margins sharply defined and circular, there is no identification of the root, the lesion is usually not cracked but may begin to peel off shortly after harvest, and the tissue is a lighter yellowish brown. Be careful not to confuse the lesions with those of Streptomyces soil rot.	-Plant least susceptible variety.	Dicloran for the seed roots.		

Fusarium wilt (Flétrissement fusarien)	Leaves turn yellow then fall off. Stunting and death of plants. Brown/purple discoloration of stem vascular bundles. Sometimes vines turn tan/light brown and stems crack.	-Use disease-free planting stocksUse resistant varieties, if availableAvoid fields with a history of wiltHold transplants for 24 hours at 29 degrees CelsiusTo reduce yield loss, plant more than one transplant per hill.	Application of neem cake to the soil.
Sweet potato virus disease complex SPFMV, SPCSV (Complexe viral de la patate douce)	Severe stunting of plants, the production of small distorted leaves, excessive branching, yellowing of vines and dark, brown to blackish corky spots in the roots.	-Use resistant variety, disease free planting materialPractice proper field sanitation.	For aphid control, see okra information.

Nematodes

Root knot nematode Meloidogyne spp.

This nematode is widely distributed throughout the world and can cause significant damage to sweet potato, especially in sandy soils. It affects both the feeder roots and the storage roots. On the feeder roots, the nematode induces galls that tend to be smaller on sweet potatoes than on many other crops. On these galls there are egg masses than can contain more than 500 eggs. Effects on storage roots vary among varieties. Swollen female nematodes, sometimes with egg masses, can be found embedded in the storage root beneath each bump or crack.

Sweet Potato				
Nematode	Damage	Available Control Measures	Pesticides	
Root knot nematode (Nématode à galles)	Plants wilt, leaves become yellow and appearance of root galls/knots of different sizes and infected roots also become enlarged and distorted. On storage rooots: cracks and rots appear or bumps.	-Weed managementCrop rotation and intercroppingPlant trap-plant like groundnut before cropMix cropping or cover cropping with non-host cropsField solarization (heat treatment)Flood the plotUse manure in nurseryAvoid growing on an infected plotDig up and let dry any attacked plantsResistant variety.	Neem cake application.	

ONION/GARLIC

Onion is a biennial vegetable grown in temperate zones as an annual. Sumerians (modern Iraq) and the ancient Egyptians were recorded using onions. Different species of wild onions exist worldwide. In the tropics the varieties that do well are in effect annuals as they can produce seed within the first year of growing. In general,

onions are used for salads (bunching onion or sliced full-grown bulbs), pickling (for example, silver skin onions), cooking (such as in soups) and frying (for example, with meat). Onions are particularly suited to smallholder farming in most countries. Today, onions are an important vegetable served on most African tables. Mostly they are grown small scale in home gardens. Onions are used as a spice in the national cuisine and produced in Niger for export. Violet de Galmi' is a Grano type onion and is the preferred cultivar in all of West Africa. It also plays an important role in traditional medicine (for example, as a diuretic). If farmers have irrigation, they will grow onions for the fresh market but rainfed onion is grown for seed. Nutrient-wise onions are a source of vitamins and minerals.

Garlic is most truly an Asian plant, but also used widely by the ancient Egyptians.

Insect pests

Onion thrips Thrips tabaci

Thrips are the most common and serious insect pest of onions, and are found wherever onions are grown. High populations of thrips can reduce both yield and storage quality of onions. Both adults and nymphs cause damage. Thrips have rasping-sucking mouthparts and feed by rasping the surface of the leaves and sucking up the liberated plant fluid. They feed under the leaf folds and in the protected inner leaves near the bulb. When population levels are high, they also feed on exposed leaf surfaces. Thrips are most damaging when they feed during the early bulbing stage of plant development. Onions can tolerate higher thrips populations closer to harvest; however, in the case of hand-topped onions, thrips can be extremely annoying to harvest crews as well. Scarring of leaves is a serious problem on green onions, since when it's severe it creates an entry point for foliar diseases. When foliage is severely damaged, the entire field takes on a silvery appearance.

Make a cursory evaluation of thrips infestation levels, by randomly sampling leaves and evaluating thrips numbers and damage under leaf folds. A far more reliable means of evaluating thrips populations, however, is to randomly sample entire onion plants. This way leaves can be pulled apart and, using a hand lens, all the thrips on the inner leaves near the bulb can be counted as well as those under the leaf folds. Sample at least five plants from four separate areas of the field. A reliable treatment threshold has not been developed; however, use a threshold of 30 thrips per plant mid-season (lower for very young plants and higher for larger mature plants) for dry bulb fresh market and drying onions.

Leaf miners Liriomyza spp.

Leaf miners are flies whose larval stage may cause damage to green onions. Farmers also spoke of an onion seedling maggot *Delia spp*, which however is a temperate pest and is not likely to be in Niger. Damage from Leaf miners is largely cosmetic, and mining on leaves may cause rejection of marketed onions, but generally does not affect plant growth, unless populations become high to prematurely kill foliage. Young plants can withstand less damage than older ones. Much more damage can be tolerated in crops where the leaf miners affect the leafy, non-marketable parts of the plant than in crops where the marketable part is attacked such as onion. Leaf miners are usually controlled by natural enemies, especially parasitic wasps. They can become a problem in areas with a high use of pesticides that kill natural enemies. They also have the ability to develop resistance to pesticides in a short time.

To monitor, look for small black and yellow flies flying closely around the crop or on the leaves. Inspect the leaf surface to reveal punctures of the epidermis and the greenish-white mines in the leaves. Look for feeding maggots at the end of the mine. Use yellow sticky traps to monitor the flies. The threshold is 25% of plants showing damage. Use an approved pesticide.

African bollworm Helicoverpa armigera

Please see the tomato section for information on this pest.

Onion/Garlic	Onion/Garlic				
Insect pests/Mites	Damage	Available Control Measures	Pesticides		
Onion thrips (Thrips de l'oignon)	End of leaves dry, and leaves get small silvery stains and curl. Distorsion as and necrosis of young flowers and fruits.	-Tolerant varietyWater plants regularlyMulch the soil with plant residuesPlough the landEliminate weedsUse trapsAvoid planting onions near grain fields, if possibleUse overhead irrigation and rainfallControl thrips before onions reach bulbing stageIn the case of hand-topped onions, treatment closer to harvest may be desirable.	Neem seed extract, spinosad, soap solution, or horticultural oil. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: Deltamethrin.		
Leaf miner (Mouche mineuse des feuilles)	Can be numerous enough to kill seedlings.	-Handpick infested seedlingsSolarization to kill pupaeConserve natural enemiesDestroy all infected leaves and other plant material after harvestDestroy pupae before planting a new cropPlowing and hoeingFlooding the soil followed by hoeing.	Neem seed extract or spinosad.		
Caterpillar leaves/African bollworm (Chenille des feuilles)	Elongated holes on leaves.	-Observe plants when they begin to growingUse insect-proof nets for nurseryPick caterpillars by handSprinkler irrigation.	Neem seed extract, tebufenozide, or nuclear polyhedrosis virus.		

Diseases

Pink root disease *Phoma (=Pyrenochaeta) terrestris*

The fungal pathogen is a common soil inhabitant that attacks the weakened roots of many plants (wounds are not necessary), generally more associated with onion (pink-root rot), penetrating its roots directly. This disease is primarily a problem on onion; garlic is infected too, but the disease rarely occurs at an economically important level. The pathogen can persist in soil indefinitely; the longer onions are grown in the field, the more destructive the disease becomes. The fungus can be spread in water and on dirty equipment and optimum temperatures for disease development are 25° to 30°C.

Infection is confined to roots and outer scales of the bulb. The most striking symptom of the disease is, as the name indicates, pink roots. Many weak *Fusarium* species can also cause pink roots, particularly on old roots; diagnosis of pink root can be accurately accomplished only on actively growing plants. Plants infected early usually produce no edible parts, while those infected later have stunted or soften bulbs. Control by fungicides through fumigation is used in developing countries. However, this is too costly for small scale farmers.

Black mold Asperaillus niger

A. niger causes black mold of onions, a post-harvest disease, in the field and also in storage, where it is the main disease. It is both seed borne and air borne. Infection of onion seedlings by A. niger can become systemic, manifesting only when conditions are conducive. The black conidia can be observed between the scales of the bulb. Invasion of the bulb begins through the neck, the pseudostem of mature bulbs, the disease or injured roots, and the bruised scales, and in a few cases at the base of bulbs. Storage in high temperatures and low humidity are not conducive for the growth of the fungus. Association of black mold with onion seeds produced in hot climates and their transmission from soil and naturally contaminated seeds to onion seedlings and sets, have also been reported and cause 30 to 80% loss/spoilage of onion bulb.

Bacterial soft rot Erwina carotovora

These organisms Soft rot is primarily a problem on onions, not garlic. The bacteria are soil-borne and free water is essential for its entry and spread. Wounds and senescent leaves are the means by which bacteria gain entrance into the bulb. Affected tissue is yellow initially, turning brown as the disease progresses lengthwise in the bulb. Also, the neck of infected bulbs may be soft when pressed.

Fusarium wilt Fusarium oxysporum f. sp cepae

Please see the tomato section on this pest.

Damping off fungi Phytophthora, Pythium, and Rhizoctonia spp.

Please see millet/sorghum and groundnut sections on this pest.

Onion/Garlic			
Disease	Damage	Available Control Measures	Pesticides
Pink root (Racine roses)	Pink and red roots and dried out. Infected roots first turn light pink, then darken through red and purple, shrivel, turn black, and die. Eventually stunted plants.	-Crop rotation after 3 yearsInfested field should be without onions for 4/6 yearsRemove weeds and plant residuesFavor a well-ventilated soilResistant variety (note that resistant varieties may be resistant in some locations but not in others)SolarizationEnsure good soil tilth and fertilityControl insects and other diseases to maintain healthy plantsAvoid planting onions after cereals.	Fumigation is too expensive.

Black mold (Moisissure noire)	Mold infects harvested bulbs.	-Early harvestRemove dead onion tissue to improve storability.	Seed treatment with thiram in endemic areas. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
Bacterial soft rot (Pourriture bactérienne)	Putrefies harvested bulbs. Yellow tissue then turns brown. Softening and water soaking of one or more of the inner fleshy scales.	 -Harvest only after onion tops are well matured. -Avoid overhead irrigation once onions start to bulb. -Provide for quick drying following topping, especially if temperatures are high. 	No nematicides available. Neem cake.
Fusarium wilt (Flétrissement fusarien)	Yellowing of the top of the leaves and browning at the bottom of the bulb. Browning and rotting of roots and appearance of white-pink fluff.	-Do not grow onions on the same field for 3/4 yearsTolerant variety.	Application of neem cake.
Damping off fungi (Fonte des semis)	Causes death and wilting of the young plants. Surviving plants may have reduced growth and yellowing leaves. A fine white powdery (the fungus) can be seen at the soil surface.	-Crop rotationAvoid wet soilsFavor good drainage and good soil aerationUse treated seedsWater only when soil is dry.	Fluopicolide or fosetyl-aluminum. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole. Seed treatment: mancozeb or

Nematodes

Stem and bulb nematode *Ditylenchus dipsaci*, Root knot nematodes *Meloidogyne sp.*, and Stubby root nematode *Paratrichodorus sp.*

The stem and bulb nematode lives within the plant, feeding in stems, leaves, and bulbs. It is capable of living without water and tolerates desiccation for several years. It penetrates the germinating clove and destroys tissue as it moves through seeking food.

Root knot nematodes live within the roots; the second stage juveniles are motile and the other stages are sedentary. Root knot infestation can cause stunting, uneven stands of plants, and produces characteristic galls on roots.

The stubby root nematode lives in the soil and feeds on the roots. Plants infested with the stem and bulb nematode have distorted and bloated tissue with a spongy appearance; the plants are stunted with shortened and thickened leaves, often with brown or yellowish spots. The bulb tissue begins softening at the neck and gradually proceeds downward; the scales appear pale gray, and the bulbs desiccate and split at the base under dry conditions. Under moist conditions, secondary invaders such as bacteria, fungi, and onion maggots induce soft rot and decay of the bulbs. Roots fed on by the stubby root nematode are extremely short with a yellow to brownish cast.

Onion/Garlic				
Nematode	Damage	Available Control Measures	Pesticides	
Stem and bulb nematode (Nématode à bulbe et tiges) Root knot nematode (Nématode à galles) Stubby root nematode	Plants wilt, leaves become yellow and appearance of root galls/knots of different sizes and infected roots also become enlarged and distorted.	-Weed managementCrop rotation and intercroppingPlant trap-plant like groundnut before cropMix cropping or cover cropping with non-host crops (carrots, lettuce)Field solarization (heat treatment)Flood the plotUse manure in nurseryAvoid growing on an infected plotDig up and let dry any attacked plantsMake sure clean, uninfested cloves are used when planting garlicClean machinery and equipment with water and prevent movement of infested soil.	Spirotetram.	

CABBAGE/LETTUCE

Cabbage Brassica oleracea is a leafy green or purple biennial plant, grown as an annual vegetable crop for its dense-leaved heads. It is called head cabbage because the immature leaves cluster up into a spherical ball or 'head' which is the part marketed and consumed. The leaves contain some carbohydraes, proteins and various essential elements (eg. calcium, iron and vitamin C). Cabbage heads generally range from 0.5 to 4 kg, and can be green, purple and white. Smooth-leafed firm-headed green cabbages are the most common, with smooth-leafed red and crinkle-leafed savoy cabbages of both colors seen more rarely. It is a multi-layered vegetable. Under conditions of long sunlit days such as are found at high northern latitudes in summer, cabbages can grow much larger. It is generally grown for its densely leaved heads, produced during the first year of its biennial cycle. Plants perform best when grown in well-drained soil in a location that receives full sun. Different varieties prefer different soil types, ranging from lighter sand to heavier clay, but all prefer fertile ground with a pH between 6.0 and 6.8.

Lettuce *Lactuca sativa* is an annual plant of the aster or sunflower family. It is most often grown as a leaf vegetable, but sometimes for its stem and seeds. Lettuce was first cultivated by the ancient Egyptians who turned it from a weed, whose seeds were used to produce oil, into a plant grown for its leaves. Lettuce is cultivated for its succulent leaves that are used in salads. They contain a high proportion of water with some ca.lcium, proteins and vitamins. Lettuce grows best in full sun in loose, nitrogen-rich soils with a pH of between 6.0 and 6.8.

Insect pests

Black cutworm Agrotis ipsilon

Black cutworm is a soil insect whose larvae feed and night and seek shelter in cracks in the soil during the day. It is a pest of seedlings as it can sever them during feeding. Young caterpillars feed on leaves and later on stems. Mature caterpillars cause the most damage, being capable of eating or destroying the entire plant. They girdle and cut-off young seedlings at ground level, dragging them into the tunnel in the soil and feed on them during the day. Thick-stemmed vegetables such as lettuce and cabbage may have the stem below the ground completely hollowed out.

Early detection to prevent serious damage: check fields for cutworm before sowing or transplanting, monitor damage by counting damaged and freshly cut leaves, freshly cut young plants, and holes in leaves and in stems. When damage reaches 10% of plants, treat with approved pesticide.

Diamondback moth Plutella xylostella

Throughout the world diamondback moth is considered the main insect pest of brassica crops, particularly cabbages, kales, broccoli and cauliflowers, and a major pest in all African countries. The economic impact of this moth is difficult to assess since it occurs in diverse small and large-scale production areas, but it has been known to completely destroy cabbage and kale crops. Diamondback moth populations can increase rapidly in warm conditions. The host finding ability of the moths are so great that they can find a potted cabbage plant in a forest. They do this by following the odor train emanating from the plant. Diamondback larvae are slender and yellow green in color and feed on leaves, growing points, stems, the inflorescence and flowers, from seedling to harvest. Before they change into brown pupae the larvae make a silk cocoon. Newly hatched caterpillars feed as leaf miners inside the leaf tissue leaving the upper leaf surface intact. Heavy damage results in the marketable parts contaminated with excrement, which makes the produce un-saleable. Larvae and pupae are found on damaged leaves where as older larvae are often found around the growing bud of young plants.

Scout for the moth regularly, at least twice a week, beginning when the plants are young; the earlier the pest is discovered, the easier it is to control. Plants should be checked thoroughly. Growing points should be carefully examined. Caterpillars that are inside the cabbage head are difficult to detect unless outer leaves are pulled back. The treatment threshold is 10% of infested plants in the seedbed, 30% infested plants from transplanting to cupping stage, 20% infested plants from cupping to early heading, and 10% infested plants at early heading to mature head stages.

Leaf miner fly Liriomyza

Leaf miners are primarily seedling pests that attack a wide variety of vegetable crops often grown in proximity to cole crops. Adults are tiny black flies with a bright yellow spot on their thorax. Farmers call it a stem maggot fly. Females puncture leaves to feed on plant sap and lay eggs within the leaf tissues. After 2 to 4 days, the eggs hatch and larvae feed between the upper and lower surface of leaves, as they move in their tunnels. Larvae emerge from the leaf mines and pupate on the leaf surface or, more commonly, drop from the plants to land in cracks in the soil. Many generations may occur each year, and the entire life cycle can be completed in less than 3 weeks when the weather is warm. Leaf miners can reduce the plant's photosynthetic capacity, render edible leaf portions unmarketable, and provide an entrance for pathogenic organisms.

Start regular monitoring during the seedling to determine the need for treatment.

Leafworms: cabbage webworm Hellula undalis, cabbage looper Trichoplusia ni

Cabbage webworm caterpillars are creamy white with light pinkish brown stripes along the body and have a black head. Mature caterpillars have faint stripes. They measure 15 mm when fully grown. Duration of larval development varies between 6 to 18 days, depending on temperature and on the host crops. Thus, on cabbage larval development is completed in 16 to 19 days, but on cauliflower it may require only 11 to 13 days.

Cabbage looper caterpillars are green, usually with a narrow white stripe along each side and several narrow lines down the back. They can be distinguished from most other common caterpillars in cole crops by their distinctive looping movement in which they arch the middle portion of their body to bring the prolegs or hind legs forward to meet the front legs. Although seedlings are occasionally damaged, most injury occurs after heading.

Young plants between seedling stage and heading can tolerate substantial leaf damage without loss of yield. Caterpillars feeding on young plants frequently cause death of the plants, especially when the larvae feed on the growing point. In older cabbage plants, new shoots are produced and the attacked plants produce several small heads of little commercial value. In addition, insect feeding and the presence of caterpillars and/or their excrement reduce the market value of the produce. On kale, young caterpillars mine in the leaves and older caterpillars bore into the stem of the plants.

Monitor regularly young plants in the nursery and after transplant. Inspect crops for the presence of caterpillars and damage symptoms. Check 25 plants selected randomly throughout the field. Look for eggs and small larvae on the underside of lower leaves. If you find holes, search the general area for the caterpillar, opening damaged heads as necessary. Base treatment on numbers of healthy larvae present (include imported cabbageworms in counts, too, if they are also present). Treat seedlings or small plants if populations of medium-sized to large caterpillars are large enough to stunt growth. Before heading, well-established plants do not need to be treated unless you find more than 9 small- to medium-sized larvae per plant.

Cabbage aphids Brevicoryne brassicae, Lipaphis erysimi

Cabbage aphids are green gray and have a simple life cycle with adult females giving birth to live offspring throughout the year. They commonly occur in dense colonies, often covered with white waxy droplets. They prefer to feed on the youngest leaves and flowering parts and are often found deep within the heads of cabbage. The honey dew they produce can result in the infection by the fungus sooty mold. This may reduce photosynthesis, affecting plant growth and yield. Cabbage aphids do not normally affect seedlings but build up after thinning or transplanting. Because of the overlapping growth of their leaves, cabbage crops require more careful management and have less tolerance for aphids even during the early vegetative stages.

Check each field at least twice a week to monitor aphid populations. Examine the undersides of the leaves and the bud areas for groups or colonies of aphids. Check for cabbage aphid in the youngest, highest, and innermost leaves of young plants. After heading, pull back wrapper leaves of cabbage. Once heads begin to form, control aphids even if only a few are present.

Treat as soon as 1 to 2% of plants are infested with one or more aphids. After treating, recheck fields frequently and treat if populations reappear with an approved pesticide.

Cabbage/Lett	Cabbage/Lettuce				
Insect pests/Mites	Damage	Available Control Measures	Pesticides		
Black Cutworms (Vers gris)	Damaged leaves and stems with holes. Attacked plants wilt and die.	-Deep tillagePlanting timeRemove weeds from border areasPlowDestroy weeds 10 to 14 days before planting the cropDelay transplanting slightly until the stems are too wide for the cutworm to encircle and/or too hard for it to cutHandpick of caterpillars at night by torch or very early morningFlood the field for a few days before sowing or transplanting.	Nuclear polyhedrosis virus, spinosad, chloranthraniliprole, Bacillus thuringiensis, neem seed extract, or Chilli and garlic extract.		
Diamond back moth (Fausse- teigne des crucifères)	Holes in the leaves, sometimes leaving only their nervations. Damage type: 'windowing' (translucent windows on the leaf). In cases of severe infestation, entire leaves could be damaged.	-Cover seedbedIntercrop with tomatoSupervise growing plantsUse insect-proof nets in nurserySprinkler irrigationSynchronous planting in each community between adjacent fieldsRemove crop debris and headsPlace seedling beds away from production fieldsRemove and destroy or plow down crop residuesPractice crop rotation, especially in semi-arid environments. 6 weeks or more where no Brassica crops are grown for by all farmers in a locality, or at least close neighbors and follow crop rotation simultaneouslyConserve and encourage natural enemies' activity.	Neem seed cake, spinosad, chloranthraniliprole, Tebufenozide, or chilli and garlic extract. Farmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: deltamethrin.		
Leaf miner (Mouche mineuse des feuilles)	Winding, whitish tunnels or leaf mines on leaves.	-Avoid planting next to infested fields, especially those near harvestConserve natural enemies, especially parasitic wasps in the Diglyphus genusChoose selective pesticides for treating other seedling pests.	Neem seed extract or spinosad. Neem oil and starch.		
Leafworms (Noctuelles)	Defoliation and damaed stems. Destroyed terminal bud, and prevention of	-Cover seedbedCrop rotationUse clean planting materials.	Neem seed extract or spinosad. Farmers can contract the		

	heading. Presence of a silken tube. Plants wilt, and excreta is exuded from the affected plant parts.	-Transplant only healthy, and vigorous insect- free seedlingsUproot and burn cabbage and kale stalks after harvest.	government to spray ULV (ultra low volume) products to large outbreaks: deltamethrin.
Cabbage aphids (Puceron du chou)	Leaves become yellow, wilt, dry, roll, and twist. Large colonies can stunt or kill small plants. Malformed flowers and fruits when aphis feed on flower buds. Honeydew accumulation on leaves.	-Put up insect-proof nets to protect nurseryWater regularly on foliageDestroy crop remnants immediately after harvestRemove or control alternate hosts, including mustards and related weeds, around field bordersBe sure transplants are clean before taking them to field.	Laundry bar soap, neem seed extract, imidacloprid, spirotetramat, pymetrozine, or horticultural oil. Rouging (removal and destruction) of infested plants from the field early during the crop cycleFarmers can contract the government to spray ULV (ultra low volume) products to large outbreaks: deltamethrin.

Diseases

Downy mildew Peronospora parasitica

Downy mildew is a disease of onions and garlic resulting in loss of yield or even a complete failure of worthwhile bulbs to form. Early symptoms on transplants may resemble bacterial leaf spot symptoms. If conditions are favorable, white fluffy growth of the fungus develops on the undersides of leaves. If disease development is extensive, leaves may take on a blighted effect as a result of numerous infection sites. In moist conditions, a white, and later purplish mold develops on leaves dead parts. This is, in turn, commonly followed by darker mold growth of other leaf-infecting fungi. Bulbs can also be infected and often sprout prematurely or shrivel in storage. The fungus requires cool, moist weather for infection and disease development to take place. It survives between crops on weed hosts or as resilient spores in crop residue. Spores are airborne. This disease is most serious on young seedlings; if cotyledons and the first true leaves are severely infected, the young plant may die.

Black rot Xanthomonas campestris pv. campestris

Black rot is one of the most serious cabbage diseases in warm climates. The black rot bacterium can overseason on infected cabbage seeds, in weeds belonging to the Brassica family, or in infected plant material in the soil. It can persist in plant residue for 1-2 years or as long as the plant debris remains intact, and can be carried on or in the seed. Black rot symptoms vary depending on the environmental conditions. Diseased plants may rot quickly before or after harvest because of secondary infection from bacterial soft-rot. Soft-rot bacteria

may invade heads of black-rot-infected plants, causing tissue to become slimy and foul-smelling. Black rot development is favored by warm, humid conditions. Splashing water from rain or sprinklers spreads the pathogen from plant to plant.

Alternaria leaf spot Alternaria brassicae

The fungus does not survive in soil, but is carried over in crucifer seed, on weed or volunteer hosts, or on undecomposed crop residue and is favored by moist conditions. Spores are spread by winds and splashing water. Spots develop on the leaves. If conditions are favorable, dark green spores of the pathogen will grow on the spots, forming concentric rings in them. Old leafspots become papery in texture and may tear. When the dry tissue falls out, a shothole effect results.

Damping off fungi Phytophthora, Pythium, and Rhizoctonia spp.

Please see millet/sorghum and groundnut sections on this pest.

Cabbage/Lettuce			
Disease	Damage	Available Control Measures	Pesticides
Downy mildew (Mildiou)	Leaves develop yellow patches that then turn tan to light brown. Then they die from the tips downward.	-Do not over irrigateDo not transplant weak seedlings or any soft, moldy or suspect onion setIrrigate in the morningAvoid sprinkler irrigationRemove crop residues after harvestingResistant varietyPractice wider spacingAvoid damp conditions and sheltered locationsMaintain good weed controlDo not compost infected material, remove and dispose of affected plantsAvoid replanting with onion for 5 yearsDo not allow any bulbs to remain in the soil from year to year.	Mancozeb, Dimethomorph, fluopicolide, or fosetyl-aluminum.
Black rot (Pourriture noire)	Angular or V- shaped chlorotic lesions along the leaf edges. With time these lesions dry up and turn tan or brown, and black veins are often seen within these lesions. Severely infected leaves may wither and drop off. When it's a systemic	-Certified seedSterilize seed in 50 degree Celsisus waterDeep plowingUse resistant cabbage varietiesCrop rotations using non-hosts and with crucifer crop no more often than every 2 years in any infested fieldRemove weed and volunteer crucifers from production areasDeep plowing and burying of all debrisAvoid sprinkler irrigation wherever possibleDo not plant infested fields during winter and spring when heavy rainfall occurs.	No bacteriacide.

	infection, vascular tissues in petioles and main stems can also turn black.		
Alternaria leaf spot (Alternariose)	Round tan spots with yellow border on leaves (0.1-0.3 mm in diameter). Elongated spots with grey center on stems.	-Use healthy seedsCrop rotation of 3/4 years if there is an infestationRemove all crop residuesAvoid watering foliage at the end of day or at nightResistant varietiesPractice clean tillage (for example, plowing)Limit crop stress, such as poor fertility, drought, insect damage, and heavy fruit.	Mancozeb. Neem oil.
Damping off fungi (Fonte des semis)	Causes death and wilting of the young plants. Surviving plants may have reduced growth and yellowing leaves. A fine white powdery (the fungus) can be seen at the soil surface.	-Crop rotationAvoid wet soilsFavor good drainage and good soil aerationUse treated seedsWater only when soil is dry.	Fluopicolide or fosetyl-aluminum. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole. Seed treatment: mancozeb, or thiram.

Nematodes

Cabbage cyst nematode Heterodera cruciferae, Root knot nematode Meloidogyne sp.

Nematodes live in soil and plant tissues and several species may occur in a field. The host range varies according to the species, with some being able to infest a wide variety of crops, and others being limited to a narrow crop range. The geographical distribution of the different species is highly dependent on temperature, soil type, and cropping history. Root knot nematode species cause typical galling on roots of infested plants.

Cyst nematodes occur frequently in cole crop-growing regions and can severely damage the crop on any soil type; all cole crops are susceptible to cyst nematodes. White, pinhead size, lemon-shaped females and brown cysts can be seen on the root surface upon careful observation. Cyst nematodes, however, do not induce gall formation on the roots.

Cabbage and lettuce			
Nematode	Damage	Available Control Measures	Pesticides
Cabbage cyst	Root knot	-Weed management.	Spirotetramat.
nematode	nematodes cause	-Crop rotation (more effective for cyst	Spray into
(Nématode à	wilted plants,	nematodes) and intercropping.	roots.
kyste)	yellow leaves and	-Plant trap-plant like groundnut before crop.	

Root knot nematode (Nématode à galles)	appearance of root galls/knots of different sizes and infected roots also become enlarged and distorted. Cyst nematodes produce stunted plants, yellow leaves and reduction in head and curd size but no gall formation.	-Mix cropping or cover cropping with non-host cropsField solarization (heat treatment)Flood the plotUse manure in nurseryAvoid growing on an infected plotDig up and let dry any attacked plantsThoroughly clean all equipment with waterDo not allow irrigation water to flow from an infested field to other fields without impoundingPrevent animal grazing and movement from infested to un-infested fieldsPlow under infested plants after harvestReduce stress on plants by proper fertilization and irrigation.	
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CUCURBITS (squash, watermelon, pumpkin)

Squashes and pumpkins are warm-season crops adapted to monthly mean temperatures of 18-27°C. Sole cropping is sometimes used for commercial production. Pumpkins and squashes are also planted in home gardens or mixed with field crops such as maize. Cultural practices to improve growth and development include the removal of growing tips (in trailing varieties) to check growth, and the bagging of fruits in paper to protect against fruit fly and other pests. Fruit setting may be stimulated by manual pollination. The fruit may rot when in contact with moist soil, so often cut grass or leaves are placed beneath the fruit. Watermelons grow best on sandy loam soils which are well drained and slightly acid. They grow best in hot climates both in the humid and drier savanna environments, but foliar diseases are less destructive in the drier climates. It requires a relatively long growing season to mature.

Pumpkin refers to certain varieties of Cucurbita moschata, C. maxima, and C. mixta. Squashes are C. maxima. Native to North America, distinguishing them is often difficult. Pumpkins have long-running, bristled stems, large deeply-lobed leaves often containing white blotches and yellow or orange flowers separated into male and female types on the same plant. The fruit is variable in shape and color but is often white, cream or green, containing about 70% flesh and several large white seeds. Fruits, leaves and flowers of cucurbits are used as vegetables, and their seeds are consumed roasted as a snack food. Pumpkin and squash are boiled and form a part of the diet of people of Niger cooked in a pot with peanut sauce and greens and served with rice and meat. Pumpkin fruit contains 1% protein and 8% carbohydrates, and the dried seeds contain 23% protein, 21% carbohydrates and up to 50% oil. Little information is available about the nutritional characteristics of cooked leaves. Watermelon Citrullus lanatus is indigenous to the dry plains of tropical and subtropical Africa, perhaps in the general area of present day Botswana. It is one of the most widely cultivated crops in the world and its global consumption is greater than that of any other cucurbit. It accounts for 6.8% of the world area devoted to vegetable production and is marketed as a cash crop. A watermelon contains about 6% sugar and 92% water by weight. As with many other fruits, it is a source of vitamin C. Notable is the inner rind of the watermelon, which is usually a light green or white color. This area is edible and contains many hidden nutrients that most people avoid eating due to its unappealing flavor.

Cotton/melon aphid Aphis gossypii

The melon aphid, also called cotton aphid, is a rather small aphid that ranges in color from yellowish green to greenish black. Both winged and wingless forms are produced. The winged individuals are somewhat slender and are not as robust as the wingless form. A mature individual measures about 0.06 inch (1.5 mm) in length. The melon aphid can be distinguished from other aphids by the color of its cornicles at the tip of the abdomen, which are always black. Unlike other aphids, melon aphid populations do not diminish with high temperatures. The melon aphid develops in colonies and prefers the underside of leaves. Initially they are present on tender parts of the plant (young shoots and leaves), but as their number increases they can cover the whole plant. As the colony grows, winged aphids are produced which fly away looking for new plants to start a new colony.

Aphids have complicated life cycles. Females can reproduce with or without mating. Female aphids may lay eggs or give birth to wingless offspring, known as nymphs. In the warm parts of the world, as in the tropics, no male aphids are produced and female aphids do not lay eggs but give birth to small nymphs. A female can produce from 20 to over 100 nymphs. Young aphids grow quickly, becoming adult in about one week and start to reproduce. Thus the numbers increase rapidly under favorable conditions. Aphids produce honey dew that favours the development of sooty mold. This may reduce photosynthesis, affecting plant growth and yield. Aphids also transmit viruses.

If unusually large numbers of aphids build up in parts of a field early in the season and appear to be retarding growth or causing honeydew buildup on fruit, apply an approved insecticide to the infested portions of the field. No threshold has been established. Early treatment does not prevent virus introduction; however, treating may help reduce spread of the virus if aphid colonies are present. Melon aphid is very difficult to control with insecticides.

Whitefly *Bemisia tabaci*

Bemisia tabaci is the dominating whitefly in the region. Whiteflies adults do not fly very efficiently, but once airborne can be transported long distances by the wind. Furthermore, all stages of the pest, particularly immature stages (which are small and easily overlooked) are likely to be carried on plant materials. They feed during seedling, vegetative and flowering stages. In addition, they often produce large quantity of honeydew that leads to the growth of sooty mould on the lower leaves, blocking or reducing the photosynthetic capacity of the plants. The honeydew also contaminates the marketable part of the plant, reducing its value or making it outright un-saleable. Damage may be more severe when plants are under water stress. Where plant viruses are transmitted, plants show the typical symptoms of the virus diseases.

Use yellow sticky traps to monitor the presence of whiteflies for timing of interventions. They have also been used as a control method for low-density infestations in enclosed environments. For early detection, inspect for adults and eggs, usually found on young leaves. Watch out for whiteflies flying up when the crop is disturbed. A cloud of tiny whiteflies flying up when the plants are shaken is a sure sign that whiteflies are abundant. The whiteflies resettle soon on the plants but the high population should have been detected sooner. Do not apply chemical intervention when only small numbers of whiteflies are present since they do not cause major direct plant damage to healthy, mature plants. Use control measures if large numbers of whiteflies are present during the early stages of the crop. However, where virus transmission is involved, even small numbers of whiteflies may need to be controlled.

Pumpkin beetle Aulacophora Africana

Pumpkin beetles adults are bright orange or orange-red in color and are readily seen during the day feeding on leaves, chewing large circular holes and often leaving only the veins of the leaves. If disturbed they will quickly fly short distances so can easily be recognized in the field. Adults lay their eggs in small clusters on dead leaves or moist soil under the plants. Larvae are creamy-white in color and about 10–12 mm long and can be found feeding on roots, but usually cause no significant damage. Older plants can tolerate a greater amount of feeding before yields start to decline.

Check seedlings twice a week and treat if pumpkin beetles are seen. Monitor older plants and treat if defoliation is severe. Try adding ½ cup of wood ash and ½ cup of lime in 4 liters water; leave to stand or some hours; strain; test on few infested plants first to make adjustment of the strength before going into large-scale spraying. Weekly monitor 20 plants and the threshold at the seedling stage is 1 adult per plant, whereas after one month the threshold is 3 adults per plant.

Fruit flies Bactrocera cucurbitae, Dacus bivittatus, D. ciliatus

There are three potential fruit fly species that could attack cucurbit crops in Niger but as there are no records per se of any species in Niger, it is not sure which ones are present. Based on distribution maps of CABI *Bactrocera cucurbitae* occurs in Mali, *Dacus bivittatus* occurs in Nigeria, and *Dacus ciliatus* occurs in Chad and Nigeria. As fruit flies can be carried long distances by breaches in quarantine by people carrying infested fruit it is probable that all three are in Niger. Fruit flies cause direct damage by puncturing the fruit skin to lay eggs. During egg laying, bacteria from the intestinal flora of the fly are introduced into the fruit, which cause rotting of the tissues surrounding the egg. When the eggs hatch, the maggots feed on the fruit flesh making galleries. These wounds provide entry for pathogens and increase the fruit decay, making fruits unsuitable for human consumption. Generally the fruit falls to the ground as, or just before the maggots pupate. Fruit flies pose quarantine restrictions for export of the fruit. Poorly managed or abandoned orchards can result in build-up of fruit fly populations.

Spider mites Tetranychus spp., Mononychellus spp., Oligonychus spp.

Generally, spider mites prefer the undersides of leaves, but in severe infestation will occur on both leaf surfaces as well as on the stems and fruits. They suck the sap of plant tissues and spin silk threads that anchor them and their eggs to the plant. The fine web produced by spider mites protects them from some of their enemies and even from pesticide applications. Hot climates and crops that are under drought stress favor spider mite population buildup. Because spider mites multiply very fast in hot weather, they are able to destroy plants within a short period of time. In addition, they become abundant as a result of excessive use of synthetic insecticides due to selective kill-off of their predators.

Control must start early. It is very difficult to control the mite population once they are established. Select randomly 20 plants and access the level of damage caused by the mites of 3 leaflets/plant by using a damage leaf index ranking from 1 to 5 (1 is few yellow spots, 5 is leaf totally covered with spots, dry patches occur). Once the average damage level reaches the second ranking, control measures should start.

Leaf miner Liriomyza trifolii

Please see tomato section on this pest.

Insect	Damage	Available Control Measures	Pesticides
pests/Mites			
Cotton/melon aphid (Puceron du cotton/melon)	Suck sap under leaves, stems and young buds. Produce honeydew that favors black fungus infestation of leaves. Leaves become yellow, twist, bend, distorted and dry and eventually wilt. Presence of black wax on attacked organs. Feeding on flower buds and fruits may cause malformed and aborted flowers and fruits.	-Put up insect-proof nets to protect the nurseryWater regularly on the foliageEnsure that the crop is well watered and well-nourished particularly with nitrogen fertilizerConserve natural enemiesSet out yellow sticky cards to monitor the movement of aphids and whiteflies before planting seed or transplants. Start checking traps after transplanting or when seedlings emerge. When aphids are observed on traps, begin monitoring crop foliage.	Neem seed extract, chili extact, soap, or horticultural oil.
Whitefly (Mouche blanche)	Remove sap, weaken plants and cause black fungus under leaves. Attacked leaves dry out, roll up, plants growth stops, and a black wax can be found on attacked organs. Infested plants may wilt, turn yellow in color, become stunted or even die.	-Intercropping, such as interplanting tomatoes with capsicum or cucumberPut up insect-proof nets to protect the nurseryYellow sticky traps reduce populationsWater regularly on the foliageAfter the last harvest, destroy all crop residuesEnsure adequate growing conditions for the cropAvoid application of high doses of nitrogen fertilizerEnsure proper spacing and good nursery managementPlant border rows of taller plants.	Spray neem seed extract, laundry bar soap, or horticultural oil. If greater control is warranted, spray spinosad, pymetrozine, horticultural oil, or imidacloprid.
Pumpkin beetle	Adult beetles defoliate as well as feed on the skin of fruit. Leafs are pierced. Flowers are destroyed and feeding on the skin of fruit causes blemishes.	-Handpick adults. -Use insect-proof net during early plant stagesBury crop residues deeplyPut wood ash at the bottom of seedlingsUse row covers 3meters long each made of fine mesh fabric. Use large, arced plastic hoops to support the row cover and give the pumpkins room to grow. Remove them when flowers open to permit pollinationPractice crop rotationDo not plant any members of the cucurbit family in the same patch as last year's pumpkin patchRemove any debris from an old pumpkin patch and plant with a cover crop, such as red cloverAvoid planting new crops next to those already infested with the beetlesProvide conditions for healthy plant growth (manures and/or commercial fertilizers, and adequate water)Straw mulches.	Neem seed extract or spinosad.

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Fruit flies (Mouche des fruits)	Distorted young fruits with drilled spot brown that softens and sinks. Inside there are maggots.	-Sow 5% or more of the land to trap crops as border strips or adjacent plots about two weeks before planting the main crop. Treat the trap crop with insecticides before adults lay eggs. -Limit the amount of irrigation water applied near harvest, and/or use irrigation systems, such as drip lines. -Plant attractant plant Euphorbia blucalli. -Shallow poughing. -Use yellow sticky or pheromone traps. -Remove fruits with dimples oozing clear sap twice a week, for the entire season. -Kill the maggots by burning, burying, or tying fruits in black plastic bags, and exposing them to the sun for a few hours. Or else feed fruits to pigs or poultry. When burying, ensure that the fruits are buried at least 50 cm (about two feet) deep. -Practice early harvesting. -Bagging, works especially well with watermelon.	Naturalyte fruit fly bait and protein hydrolysate and spinosad. Coffea robusta leaf extract bait is also found to be highly attractive.
Spider mites (Tétranyque)	Produce silver yellow spots, leaves wilt and dry. Brown areas on stems. Fruits with crackled aspect. First symptoms are usually clusters of yellow spots on the upper surface of leaves, which may also appear chlorotic and get a speckled or mottled appearance. Attacked leaves turn bronze, or rusty, purple or yellow brown color.	-Set out fruit fly traps baited with curelure. -Install windbreaks around the fieldLeave a distance between the crop and the field bordersFavor sprinkling irrigation on leavesRemove crop residues after harvestAvoid water and nutrient stress by applying mulch and incorporate organic matter into the soilUproot and burn infested plants during the early stages of infestationKeep the field free of weedsMake a moist microclimate by increasing plant density (note that this could enhance fungal diseases, so care should be taken)When weeding, harvesting, or doing any other fieldwork, leave the infested area until last to minimize the spread of mitesInspect your field regularly.	Neem, horticultural oil, or laundry soap (but test on leaves before since it can damage them until 2 days after application). Neem oil and canola oil.
Leaf miner (Mouche mineuse des feuilles)	Mines and white marks on the leaf surface.	-Install insect-proof nets to protect the nurserySpray repellent substances of garlic, onion, or red pepperPerform a shallow ploughingRemove crop residues.	Neem oil and starch.

Diseases

Anthracnose of cucurbits Colletotrichum lagenarium

The lifecycle of anthracnose diseases involves essentially production of spores on susceptible hosts, dispersal of spores, penetration of host tissue, initiation of an infection process within the cells, development of lesions,

formation of bristly spores and dispersal. The anthracnose pathogen reaches its most serious dimension at high moisture and warm temperature. Spore germination, dispersal and infection require relative humidities near 100%. However, in drier situations disease expression can occur when latent infections are activated through aging or tissue damage. The anthracnose diseases are primarily transmitted through seed, but also through infected plant parts, insects or other forms of contact. Rain splash and moist wind will also disperse spores within crop canopy. The pathogen persists on and in seed, crop residues, and weed hosts. Anthracnose diseases attack all plant parts at any growth stage.

Powdery mildew Sphaerotheca fuliginea, Erysiphe cichoracearum

All cucurbits are susceptible to powdery mildew, but the disease is less common on watermelon. Even though there are several types of powdery mildew fungi, they all produce similar symptoms on plant parts. The white powdery growth consists of large numbers of fungal spores, which are spread by wind. The disease can spread very rapidly. The pathogens generally overwinter on weeds. Powdery mildews are severe in warm, dry climates because the fungus does not need the presence of water on the leaf surface for infection to occur. However, the relative humidity of the air needs to be high for spore germination. Therefore, the disease is common in crowded plantings where air circulation is poor and in damp, shaded areas. Young, succulent growth usually is more susceptible than older plant tissues.

Start monitoring for powdery mildew during the vegetative growth stage and continue through fruit development. Carefully monitor even those fields with powdery mildew resistant varieties.

Downy mildew Pseudoperonospora cubensis

It attacks all cucurbits, although cucumber is the most commonly infected, and occurs in all plant stages but is more common in the late season. The disease can cause severe damage to seedlings in the seedbed. Older leaves usually remain attached. Infected flowers abort and drop. Older leaves become infected first. Spores of the fungus are carried by air currents or by rain-splash or sprinklers. Dew and cool weather also favor this disease. Start monitoring during the vegetative growth stage and until fruit development. Monitor weekly.

Mosaic virus diseases cucumber mosaic virus (CMV), watermelon mosaic virus (WMV), zucchini yellow mosaic virus (ZYMV)

Many viruses affect the cucurbit family. The important viruses include cucumber mosaic virus, watermelon mosaic virus and zucchini yellow mosaic virus. All are transmitted in a non-persistent fashion by aphids (*Aphis gossypii, Myzus persicae*) who acquire the virus from an infected plant and then transmit it to a healthy plant with their probing. Aphids can acquire CMV from an infected plant in 10 to 30 seconds and transmit the virus after feeding for as few as 9 seconds. They are also transmitted by pumpkin beetles via mechanical means in plant sap carried on their mouthparts. For ZYMV, there is evidence of transmission by seed (at a very low level), but not for the two other viruses.

CMV has a very extensive host range including carrots, cowpeas, onions, potatoes and tomatoes. WMV is known from two strains: 1) papaya ringspot virus-watermelon strain 1 (PRSV-W), formerly known as watermelon mosaic virus and 2) watermelon mosaic virus strain 2 (WMV-2). Its host range is primarily restricted to cucurbits. ZYMV has a global distribution.

Field symptoms of these 3 diseases are similar and therefore it is very difficult to separate them by symptoms alone. When crops are fully infected before fruit set, severe yield losses of up to 95% occur. These losses reflect reduction in the weight of fruit produced and also quality defects consisting of misshapen and discolored fruit rendering them unmarketable. Infected fruit also have reduced shelf life. Monitor the crop weekly and if the

field is in an endemic virus. Place yellow sticky traps on the field borer. When aphids appear, control them with approved insecticides. See aphid control in this section.

Papaya ringspot virus

Papaya ringspot virus infects papaya and cucurbits systemically. It is a potyvirus and is transmitted between plants by mechanical activities like pruning and by numerous aphid species such as Myzus persicae. No seed transmission has been detected. In cucurbits, leaves show intense mosaic with a narrowing of the leaves. Severe cases can result in a shoestring effect similar to what is observed in papaya. Plants that become infected at a young age do not develop a crop. Older plants that become infected do produce fruit that often show distinct changes in color and are deformed. The virus, PRSV, is transmitted nonpersistently by aphid vectors and does not multiply in the vector. The disease cycle can start with aphids feeding on infected papaya for as little as 15 seconds and subsequently feeding on a healthy papaya. There is no incubation period. The various options for managing viral diseases are vector control, planting in areas where there is no virus, roguing, cross protection, and resistance. Vector control for managing PRSV is not an economical option for several reasons. PRSV is non-persistently transmitted and thus the vector acquires and transmits the virus within seconds to minutes. Thus, aphids coming into target areas of vector control could acquire and shortly thereafter transmit the virus, and insecticides cannot kill them fast enough.

Fusarium wilt Fusarium oxysporum f. sp cepae

Please see the tomato section on this pest.

Damping off fungi Phytophthora, Pythium, and Rhizoctonia spp.

Please see millet/sorghum and groundnut sections on this pest.

Cucurbits (squash, watermelon, pumpkin)			
Disease	Damage	Available Control Measures	Pesticides
Anthracnose (Pourriture rouge)	Symptoms most visible on leaves and ripe fruits. At first, small and irregular yellow, brown, dark-brown or black spots that can expand and merge. Sometimes cankers on stems. Infected fruit has small, water-soaked, sunken, circular spots (up to 1 cm in diameter). As it ages, the center of an older spot becomes blackish and emits gelatinous pink spore masses.	-Resistant varietyControl weeds and rogue infected plantsUse healthy seedsCrop rotation of 3 years without solanaceaeAvoid overhead wateringHarvest fruits as soon as ripeInspect transplantsSelect healthy plants for transplantingPull out plants that are heavily infected and bury themPick rotten fruits and bury in a pitPlow under the crop residues, as well as straw mulches.	Thiram seed treatment or soak seed with bleach or hot water if not certified seed. Seed treatment: thiamethoxam, mefenoxam, and difenoconaz ole. Mancozeb.
Powdery mildew (Oïdium ou Blanc)	Pale yellow spots on stems, petioles, and leaves (especially upper sides) that enlarge as the white,	-Resistant varietyWide spacingSolarizationRemove weeds and plant residues.	Sulfur, azoxystrobin, or kresoxim- methyl.

	fluffy mycelium grows and produces spores, which give the lesions a powdery appearance. Affected leaves become dull, chlorotic, eventually they become brown and papery. Diseased flowers fail to open and no fruit is formed. Skin cracks on fruits.	-Follow good sanitation practicesAvoid late-season applications of nitrogen fertilizerAvoid overhead wateringRemove and destroy all infected plant partsSelectively prune overcrowded plant material.	
Downy mildew (Mildiou)	Pale green or yellow angular spots that later is covered with whitish-purple growth. Mottled appearance foliage. Eventually the spots coalesce and the leaf turns brown. Purplish discoloration of the upper leaf surface sometimes. Young leaves and cotyledons may drop off when yellow.	-Wide spacing and prune new growth for aerationBurn tomato and potato plants with symptomsAvoid watering on foliageResistant varietyUse only certified diseased-free seeds for sowingPractice crop rotationTransplant only healthy seedlingsEnsure proper land preparation to make sure that your soil is well drainedPlant earlyRemove weed hosts found in between cropsRemove and destroy crop residues after harvest.	Mancozeb, cyazofamid, Dimethomorph, fluopicolide, or fosetyl- aluminum.
Mosaic viruses CMV, WMV, ZYMV (Virus de la Mosaïque)	Leaf mottling or mosaic light and green patterns. Leaves become distorted and wither in the ZYMV. Reduced and smaller fruit set. In severe cases, leaf distortion whereby affected leaves appear fern-like. Diseased fruits are malformed with slightly to severely misshaped with wart-like lumps.	-Resistant varietyRogue infected plantsWeed the plot and contaminated plantsRemove infected plantsDisinfect hands and tools with 70% alcohol after contact with infected plantsPurchase certified seedUse row covers 3meters long each made of fine mesh fabric. Use large, arced plastic hoops to support the row cover and give pumpkins room to grow. Remove when flowers open to permit pollination.	Control aphids, see above.
Papaya ring spot virus (Virus des taches en anneau du papayer) (PRSV)	Leaves yellowing then shape mosaic and lightening of nervures. Sometimes stunting of the plant. Round spots on stems. On fruits dark green ring spots that can turn brown or grey at maturity. Fruits may also have deformities.	-Dig out infested plants and burn themObserve plants to detect aphids.	
Fusarium wilt (Flétrissement fusarien)	Branches or whole plant wilts from the bottom to the top. Yellowing on one side of the plant which	-Sterilize nursery bed soil by burningIncrease soil pH to 6.5 to 7.0 with lime or fertilizersCrop rotation of 3/4 years without cucurbits if there is an infestation.	No fungicides are very effective.

	withers and dies. Browning	-Remove crop debris after harvesting.	Application of
	of the inside part of the		neem cake.
	stem. Roots stunt.		
Damping off	Causes death and wilting	-Crop rotation.	Fluopicolide or
fungi	of the young plants.	-Avoid wet soils.	fosetyl-
(Fonte des	Surviving plants may have	-Favor good drainage and good soil aeration.	aluminum.
semis)	reduced growth and	-Use treated seeds.	
	yellowing leaves. A fine	-Water only when soil is dry.	Seed treatment:
	white powdery (the		mancozeb or
	fungus) can be seen at the		thiram.
	soil surface.		

Nematodes

Root knot nematodes Meloidogyne spp.

Meloidogyne are by far the most important plant parasitic nematodes in cucurbits. All cultivated cucurbits are very susceptible to the southern (M. incognita) and Javanese (M. javanica) root knot nematodes while they are poor hosts to the northern root knot nematode (M. hapla). In the presence of sufficient soil moisture, second stage juveniles hatch from eggs and invade host roots at soil temperatures above 18°C. Once inside the root, the juveniles soon become immobile while establishing a feeding site that sustains them through three additional molts to the adult stage. This life style is classified as sedentary endoparasitic. These may grow to one inch or more in diameter and harbor one or more of the developing nematodes, and result in reduction of water and nutrient transport. The development rate of nematodes is temperature related. At soil temperatures of 25° to 28°C, the optimal range for the development of root knot nematode species, they complete their life cycle within 3 to 4 weeks. Each female produces an egg mass that contains several hundred eggs embedded in a protective gel. The eggs are immediately ready to hatch. Crop damage is greatest in warm regions with coarser-textured soils such as sand or sandy loam.

Cucurbits (squash, watermelon, pumpkin)			
Nematode	Damage	Available Control Measures	Pesticides
Root knot nematode (Nématode à galles)	Plants wilt, leaves become yellow and appearance of root galls/knots of different sizes and infected roots also become enlarged and distorted.	-Weed managementCrop rotation with non-host crops for 3 yearsPlant trap-plant like groundnut before cropMix cropping or cover cropping with non-host cropsField solarization (heat treatment)Flood the plotUse manure in nurseryAvoid grow ing on an infected plotDig up and let dry any attacked plantsDeep plowing and fallowing.	Spirotetramat (Movento) crop spray systemic action into roots

SESAME

Sesame, originated in East Africa, is the oldest of the commercial oil seeds. Sesame is an excellent rotation crop of millet, groundnut, and sorghum. It reduces nematode populations and is also an excellent soil builder as it improves the texture and moisture retention and lessens soil erosion. The composted sesame leaves left on the soil bind the ground and retain soil moisture better for planting the next crop. Sesame is resistant to drought, tolerant to insect pests and diseases, a low cost crop and therefore one of the best alternative specialty crops. Purely white sesame seeds are in demand on conventional and on ecological markets, because of their higher oil content than pigmented varieties. The oil is a clear edible oil with a pleasant taste and a very good long shelf life if properly refined. Sesame has an oil content of 48-55% which is the highest of any oil crop while the protein content ranges from 44 to 48%. By-products of oil extraction are an excellent protein component to mix into animal feed. Sesame is grown as a cash crop and has a large market as an oil crop. Sesame seeds are either consumed directly as a highly nutritious foodstuff or processed by the confectionery and bakery industries. Sesame hay, if carefully dried, can be used as fodder. Due to its drought tolerance, it is suited to be planted in bio-reclaimed lands. The oil is used for cooking and is very stable and free from undesirable nutrition and flavor characteristics. It is rich in protein comparing well with soybean. Because of the high unsaturated fat and methionine content, sesame seed and oil are in high demand in as an export crop.

Insect/mite pests

White fly *Bemesia tabaci*

Whiteflies adults do not fly very efficiently, but once airborne can be transported long distances by the wind. They are vectors of leaf curl virus of sesame. Whiteflies are extremely polyphagous, they feed by tapping into the phloem of plants, introducing toxic saliva and decreasing the plants' overall turgor pressure. This produces honeydew, which is conducive to the development of sooty mould and also attracts ants and causes yellowing of leaves. Whitefly incidence is favored by dry conditions. Since they congregate in large numbers, susceptible plants can be quickly overwhelmed. A cloud of tiny whiteflies flying up when the plants are shaken is a signal of their presence. They resettle soon on the plants.

Place yellow sticky traps in the field to monitor infestations. In areas where leaf curl virus is endemic, the crop must be free of whiteflies during the first month of planting. When 1 whitefly is found in 5 plants, begin approved insecticide protection. If there is no virus, then the threshold is higher.

Green peach aphid Myzus persicae

Aphids are major pests that passively feed on sap of phloem vessels in plants. Once a phloem vessel is punctured, the sap, which is under high pressure, is forced into the aphid's food canal. They are soft-bodied, and have little protection from predators and diseases. Small populations may be relatively harmless, but heavily infested plants usually have wrinkled leaves, stunted growth and deformed capsules. Though aphids cannot fly for most of their life cycle, they can escape predators and accidental ingestion by herbivores by dropping off the plant they are on. Due to hot temperatures in Niger they can undergo more than 40 generations per year where one generation takes only 9 days, each female producing 20 offspring. All the aphids are females during the growing season and they reproduce by giving birth so that inside each female is a female nymph and inside her is an egg so that three generations are represented by each adult female. Males form in the winter season each year. Vigorous plants can replace the lost nutrients taken up by the surprisingly high density of feeding aphids of 100 aphids per sesame plant, without yield loss.

Webworm Antigastra catalaunalis

The sesame webworm is a major pest that feeds on the sesame crop from seedling to flowering and capsule stages. In a young crop, the webworm makes webs in the upper portion of plant to draw together leaves offering protection while it feeds. At flowering stage, it feeds on the flowers and at capsule stage, it bores into the capsules to consume the developing seeds. As a result, 20 to 50 % loss of yield can occur, particularly from an early infestation of the crop. One to three larvae are enough to denude a full-grown plant within 24 to 48 hours. Most serious damage is caused during the flowering and podding period. A generation takes just over three weeks to complete. It passes the dry season in dormancy in crop residues. Monitor the crop weekly. If defoliation reaches 25%, spray spinosad or neem seed extract.

Sesame gall midge Asphondylia sesami

The sesame gall midge is usually a minor pest, but occasionally high infestations occur resulting in considerable crop losses. The adult is a 5 mm long red-bodied midge (mosquito-like fly). Female midges lay eggs along the veins of terminal sesame leaves. The larvae are typical maggots; they are whitish to orange in color, legless and with body tapering exteriorly and grow up to 4 mm in length. Maggots feed inside the floral buds and young capsules leading to formation of galls, where they pupate. The gall midge attacks during flowering and become particularly abundant if planting is staggered or varieties of different maturity periods come to flower over a long period, as this leads to multiple generations to develop.

Monitor plants at the time of bud initiation and look for galls among the first plants to develop. Use neem seed extract when the threshold of 1 gall per plant is reached.

Leafhopper Emposaca

Leafhoppers are wedge-shaped, often green colored and about 3mm long plant-feeders. Their body is widest at the head and tapers toward the wing tips. Their hind legs are modified for jumping which they are quick to do when disturbed. They also move crab-like sideways as nymphs and adults particularly on the undersides of leaves which is their favorite habitat. Eggs are laid singly within the petioles and veins on the under surfaces of host foliage. Nymphs hatch from eggs and pass through five distinct stages within a period of two weeks in hot climates. Leafhoppers have piercing-sucking mouthparts, enabling them to feed on plant sap from a wide and diverse range of plants. Plant sap is removed directly from the vascular (water and food transport) system in the leaflet, petioles, and sometimes the stem. In the feeding process, the leafhopper injects a salivary toxin that causes injury to the plant and appears very similar to disease symptoms or nutrient imbalance. By adversely affecting the vascular system, leafhoppers reduce photosynthesis, decrease productivity, stunt the plant, and sometimes kill young seedlings. In sesame, aside from direct damage, leafhoppers are also a vector of phyllody disease. Plant damage is frequently intensified during periods of moisture stress.

Effective control often requires the use of chemical insecticides. These should be applied when potato leafhopper populations reach specific economic threshold levels and before symptoms of feeding injury become widespread. On beans, a population equal or exceeding an average of 1 nymph/trifoliolate leaflet or 50 adults/I0 sweeps can cause economic loss and indicates the need for control. For potato the ET is 10 nymphs per I00 leaves.

Spider mites Tetranychus spp.

Spider mites adults are about 0.3 -0.6 mm long, reddish, have eight legs, and produce fine silk webbing that protects them from predators and pesticide sprays. Eggs of red spider mites are round, white or pink and of size about 0.1 mm, and are usually laid on the under-surface of leaves. They hatch into six-legged larvae, light green in color. Spider mites feed on the plant and result in infested leaves being spotted, yellowish or silvery.

Infested capsules exhibit white speckling. The red spider mites are dispersed by wind and human activity on clothes while working in infested fields. Also, warm weather and insufficient rains favor their development.

Sesame	Sesame				
Insect pests/ Mites	Damage	Available Control Measures	Pesticides		
Whitefly (Mouche blanche)	Remove sap, cause black fungus under leaves. Attacked leaves dry out, roll up, plants growth stops, and a black wax can be found on attacked organs.	-Put up insect-proof nets to protect the nurseryYellow sticky traps reduce populationsWater regularly on the foliageAfter the last harvest, destroy all crop residuesRemove weedsPlanting timeUse pubescent varieties that offer some resistanceAvoid the season when whiteflies are more likely to occurGrow flowering plants around the fieldAvoid pesticide spraying to maintain parasitoids.	Spray neem seed extract, laundry bar soap, or horticultural oil. If greater control is warranted, spray spinosad, pymetrozine, or imidacloprid.		
Green peach aphid (Puceron vert du pêcher)	Suck sap under leaves, stems and young buds. Produce honeydew that favors black fungus infestation of leaves. Leaves become yellow, distorted and dry. Presence of black wax on attacked organs. Stunted growth and deformed capsules. Decreased flower and seed production and viability.	-Put up insect-proof nets to protect the nurseryWater regularly on the foliageEnsure that the crop is well watered and has received balanced nutritionConserve natural enemies by using selective insecticidesMonitor weekly the crop and consider using yellow sticky traps.	Horticultural oil or neem oil.		
Webworm (Pyrale)	Larva fastens leaves together with silk and remains inside feeding. Seed consumption.	-IntercroppingHave a well-nourished crop (including use of inorganic and organic fertilizer).	Spinosad or neem seed extract.		
Sesame gall midge (Cécidomyie du sésame)	Formation of galls. Attacked flower buds wither and drop, or become twisted and stunted and do not develop in to flower/capsules.	-Resistant variety (prefer plants with black capsules to ones with green capsules)Synchronous plantingIntercrop with mungbean, pearl millet, or groundnutSynchronous plantingClip the galls and burn the buds.	Neem seed extract.		

Leafhopper (Cicadelle)	It sucks the sap from the under side of the leaves. The injured leaf margins turn yellow then brown and tend to curve downward. Leaves dry and can fall down.	-Conserve natural enemies (like parasitic wasps species) by using selective insecticidesIntercroppingObserve plants at beginning to identify symptoms as soon as possiblePlant resistant varietyBalanced plant nutritionAvoid to grow near malvaceae or solanaceae.	Laundry bar soap or neem seed extract. Apply insecticide when first damage appears, particularly at seedling stage. No treatment is necessary after fruiting.
Spider mites (Tétranyque)	Colonies can be found feeding on ventral surface of leaves, resulting in yellow spots on dorsal surface.	-Crop resistanceWeed managementGood field hygieneEnsure adequate crop nutritionEncourage natural enemies by, for example by planting flowering plants around the fieldUse selective insecticides to prevent secondary pest outbreak of mitesMonitor the crop weekly looking for mites.	Sulfur WP, neem seed extract, horticultural oil, or sulfur and canola oil.

Diseases

Damping off fungi Pythium, Sclerotium, Fusarium

This soil-borne fungus attacks young seedling. It is especially present after weeding. Infestation results in the stem becoming water soaked soft and incapable of supporting the seedling which falls over and dies. Rotting of the seed or germinating seedling in the ground often escapes attention and poor stands are frequently erroneously attributed to inferior seed. The disease is exacerbated by water logging usually after heavy rains on heavy soil.

Leaf spot Alternaria spp.

This seed-borne pathogen attacks all parts of the plant at all stages, affecting leaves of plants as early as 4 weeks after planting. Milder attacks cause only defoliation but in severe cases the plant may die. Extensive infection of foliage and capsule leads result in yield losses that may range from 22 to 53%. The disease is favored by temperatures of 20-30° C and humid conditions.

MLO phyllody

Phyllody is a destructive disease of sesame caused by a mycoplasma like organism (MLO), capable of inflicting 33% yield loss in other countries. Leafhoppers are suspected vectors but not much is known about the disease.

In India, where this disease has been studied, insecticides can control the leafhopper vector but cannot stop the transmission of the disease. However, they tested a number of varieties and found tolerance among them.

Leaf curl virus

The leaf curl virus is a geminivirus found in Nigeria that can cause serious yield loss, especially if the infection occurs in the early crop growth stages. The white fly *Bemisia tabaci* vectors the disease. Severely affected plants remain stunted with few flowers and capsules, sometimes there is no flowering and capsule production, especially if infection began early in crop growth.

Sesame	Sesame			
Disease	Damage	Available Control Measures	Pesticides	
Damping off fungi (Fonte des semis)	Water-soaked stem. Plant wilts and dies. Elongated brown lesions on older seedlings.	-Plant on ridgesWide spacingAvoid water stress by planting earlyPlant on ridges and amend the soil with compostUse pathogen-free seeds.	Fluopicolide or fosetyl-aluminum. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole. Seed treatment: mancozeb or thiram.	
Leaf spot (Alternaria)	Small, dark brown water soaked, round to irregular lesions, with concentric rings, 1-8 mm in diameter appear on the leaves. The lesions may also appear on the midrib and veins of the leaves.	-Crop rotation of 3/4 years if there has been an infestationRemove all crop residuesAvoid watering foliage at the end of day or at nightResistant varieties (for example, varieties totally covered with hair)Use certified disease-free seedsEarly planting immediately after onset of rainsIntercrop sesame with other cropsMonitor the crop weekly.	Mancozeb.	
Mycoplasma- like organism MLO phyllody (Phyllodie)	Stunted plants. The capsules abort and open exposing developing seeds. Floral virescence (abnormally turning green), phyllody and proliferation. Yellowing, cracking of seed capsules, germination of seeds in the capsules, formation of dark exudates on the foliage. Abundant abnormal branches bend down.	-IntercroppingUse tolerant varietiesRoguing of infected plantsAdjust the planting time to one where disease prevalence is lowControl the leafhopper vector with insecticides.	Laundry bar soap or neem seed extract. Apply when first damage appears, particularly at seedling stage. No treatment is necessary after fruiting.	

Leaf curl virus Curli (Virus de thick l'enroulement leaf sthick also turni	ling of leaves, vein kening, reduction in size, brittleness and kening. Leaves may become leathery, ning dark green apared to uncurled	-Place fine mesh row covers over the cropAll other measures center on controlling the vector.	Control whitefly, see above
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CARROT

Carrots, native to Asia, are the most common vegetable root crop grown in West Africa and an important source of Vitamin A in human diets. Vitamin A deficiency can lead to blindness and, especially for children, to a greater risk of dying from ailments such as measles, diarrhea or malaria. Carrot roots are rich in betacarotene, as well as carbohydrate and moderate amounts of protein. They are consumed raw or cooked, alone or in combination with other vegetables (for example, peas), as an ingredient of soups, sauces and in dietary compositions. Young leaves are sometimes eaten raw or used as fodder. Carrots are grown as cash crops in areas favored by irrigation.

Insect pests

Aphids Aphis gossypii, Mysus persicae

The cotton/melon aphid A. gossypii and the green peach aphid M. persicae are likely potential pests and come to carrots to feed on the green tops from adjacent fields with more of their preferred hosts. Generally, these aphids are much less harmful than if they are virus vectors. Currently no virus diseases are known in West Africa.

Green peach aphid can be found at any time throughout the year. It is medium-sized and both winged and wingless forms have prominent cornicles slightly swollen and club-like in appearance. The winged forms have a distinct dark patch on the top of the abdomen; wingless forms lack this dark patch and are uniformly pale green in color. The cotton/melon aphid is a small to medium-sized, highly variable in color, ranging from lemon yellow to blackish green in different individuals, often within the same colony. The aphid is commonly lighter in color during the hotter times of the year and darker during cooler periods, but both color forms may be found throughout the year. Infestations on young plants are more serious than those on older plants.

Monitor fields for aphids weekly during spring and summer by examining the upper and lower surfaces of leaves. Also, look for evidence of predators and parasites and their impact on aphid populations. Small colonies occasionally develop on carrot leaves and may reach treatable levels.

Carrot			
Insect pest	Damage	Available Control Measures	Pesticides

Aphids	Suck sap under	-Put up insect-proof nets to protect the	Horticultural oil
(Pucerons)	leaves, stems and young buds. Produce honeydew that favors black fungus infestation of leaves. Leaves become yellow, distorted, curl and dry. Presence of black wax on attacked organs.	nurseryWater regularly on the foliageBalanced crop nutrition to build up the crop's tolerance of sap removalWeedingConserve natural enemies (green lacewing, lady beetles, and syrphid flower fly larvae).	or neem oil.

Diseases

Damping off Alternaria spp., Fusarium spp., Pythium spp., Rhizoctonia solani

Damping-off diseases are caused by a complex of four soil-borne pathogens, either individually or most likely in combination with two, three, or all four. These soil-infesting fungi or fungus-like microorganisms are widespread and attack young and germinating seedlings of many plants. Infected plants seldom recover. The most predisposing factors are use of non-certified disease-free seeds and excessive watering of seedbeds or field plots.

Powdery mildew Sphaerotheca fuliginea, Erysiphe cichoracearum

Please see the Curcurbits section for general information on this pest.

Root dieback Pythium

The pathogens of Root dieback are spread in water and soil. *Pythium spp.* can also cause damping-off of carrots. In addition, forking and stubbing can also be caused by hardpans, nematodes, and excessive water, among other factors. Only very young tissue is susceptible. The severity of the disease may be dependent on the density of thick-walled *Pythium* dormant forms of the pathogen in field soils. Very wet soil conditions favor the disease.

Alternaria leaf blight Alternaria dauci

Alternaria leaf blight pathogen survives on and is spread on carrot seed, debris and on volunteer carrots. However, once the crop residue decomposes, the fungus dies. Spores are dispersed in air and splashing water. Leaves weakened by blight may break off when gripped by mechanical harvesters, resulting in the roots being left in the ground. Lesions that develop on petioles may kill entire leaves. The pathogen also causes damping-off of carrot seedlings. The disease is favored by rainy weather and/or overhead irrigation. The optimum temperature for growth and infection is 28°C with some infection occurring at temperatures as low as 14°C and as high as 35°C.

Carrot			
Disease	Damage	Available Control Measures	Pesticides
Damping off	Seedlings wilt and die.	-Clean seed.	Fluopicolide
fungi	Seedlings attacked at ground	-Plant on ridges.	or fosetyl-aluminum
	level develop a water-	-Wide spacing.	

(Fonte des semis)	soaked, discolored stem and topple over. Seeds may rot before emergence and seedlings die after emergence.	-Avoid water stress by planting earlyPlant seedings on raised beds in well-drained fields.	Seed treatment: Mancozeb or Thiram. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
Powdery mildew (Oïdium ou Blanc)	White powdery film and yellow/brown spots on the leaves, they can dry and become brittle.	-Remove weeds and plant residuesPractice overhead wateringUse treated seeds.	Neem oil. Sulfur.
Root dieback (Dépérisseme nt des racines)	Excessively branched or stubbed roots and killed young taproots less than two weeks after seed germination, reducing root length and/or stimulating multiple root formation (forking).	-Avoid overwateringProvide good drainageCrop rotation.	Cyazofamid or mefenoxam.
Alternaria leaf blight (Alternariose)	First black spots with yellow borders appear on leaves and petioles, then larger brown spots. On fruit spots start at the attachment point.	-Resistant varietyRemove crop debrisDisinfect seedsCrop rotation of 3/4 yearsAvoid watering the foliage at the end of the day or at nightTurn under carrot residue by tillage or plowingDo not plant new fields near existing fields with blight symptomsIf possible, use furrow irrigation.	Disinfect the seed with sodium hypochlorite or treat the seed with thiram. If disease is spreading, spray with mancozeb.

Nematodes

Root knot nematodes *Meloidogyne* spp., Needle nematodes *Longidorus* sp., Stubby root nematodes *Trichodorus* sp., *Paratrichodorus* sp.

Nematodes are the key pest of carrots and are most prevalent on sandy and light soils. Among nematodes that affect carrot, root knot nematodes are the most important and are widely distributed. Root knot nematodes enter the roots as second stage juveniles where they remain to feed. Second stage juveniles are mobile, but the other stages are sedentary. During the development in carrot roots, later-stage juveniles and adult females increase in size. The enlarged posterior end of adult females breaks through the root surface and produces an egg mass just outside the root or just beneath the root surface. Adult root knot nematodes and their egg masses are visible at 10X magnification.

Needle nematode and stubby root nematodes are migrating ectoparasites (ie. they feed on but do not penetrate into the roots) and lay eggs singly in soil. They go through four molts and all juvenile stages probably feed on roots. Both needle nematode and stubby root nematode need to be extracted from the soil to be seen under high magnification.

Root knot nematodes can cause substantial damage. Their parasitic activity can damage the growing root tip and result in a forked, distorted, or stunted taproot, typically within the first weeks after seed germination. In addition to the reduced marketability, deformed roots tend to pick up excess soil, increasing the tare transported to the shed. Removal of excess soil increases cost.

Carrots				
Nematode	Damage	Available Control Measures	Pesticides	
Root knot nematode (Nématode à galles) Needle nematodes (Nématode à lancette) Stubby root nematodes	Plants wilt, leaves become yellow and appearance of root galls/knots of different sizes and infected roots also become enlarged and distorted. Root elongation, forking, root branching, swelling of root tips, and sometimes root tip necrosis. Stunting, branching, and swelling at root tips.	-Weed managementCrop rotation (but not very effective for root knot nematodes) and intercroppingPlant trap-plant like groundnut before cropMix cropping or cover cropping with non-host cropsField solarization (heat treatment of 4/6 weeks)Flood the plotUse manure in nurseryAvoid growing on an infected plotDig up and let dry any attacked plantsUse new carrot cultivars that show resistance to root knot nematode damage (forking and galling)Amend the soil with compost.	Spirotetramat. Spray into roots.	

MORINGA

The drumstick tree *Moringa oleifer*a is a member of the plant family Moringaceae which has only one genus Moringa and about thirteen species growing in Madagascar, northeast and southwest Africa, and Arabia, with three species spreading to India. Moringa is a slender, fast growing, deciduous shrub or small tree reaching 9 to 15 m in height, with an umbrella shaped, open crown. It is an exceptionally nutritious tree with a variety of potential uses despite the foliage of Moringaceae often smells unpleasant when crushed. It was believed to be native to India-Pakistan-Nepal borders. It has been cultivated for use as food, medicine and feed. It is being spread far and wide as a food crop especially for under nourished farm communities by aid agencies.

As a vegetable, the plant possesses various edible parts (leaves, tender pods and fruits, flowers, etc.) with high nutritional and medicinal values. They are rich in proteins, minerals (AI, Ca, K, Na) and vitamins (A, C, B, etc). The leaves are the most nutritious parts with high levels of important vitamins and all the essential amino acids. Important secondary metabolites such as tannins, saponins, and alkaloids were also found, which seem to contribute to its medical properties. The Moringa tree, takes about eight months to bloom, and they germinate easily from seeds, saplings, or cuttings. They can even grow in poor soil and require less labor than other trees.

Moringa is a host to only few pests and diseases, but outbreaks may occur under certain conditions. The pests divide into those that are adapted to species in the family Moringaceae, and those that are generalists. There are severe losses from time to time from members of both classifications. Termites and soil borne fungi are the generalists while budworm is only recorded on species of Moringa. Thus when Moringa was introduced, the budworm quickly adapted as it fits with the Northeast Africa location of Sudan and may have subsequently been brought by people traveling from there carrying cuttings. Only three pest groups are presented in detail while the others are polyphagous generalist pests that rarely become very numerous. These records come from other countries. If any of these subsequently become serious pests, the control measures for other members of their relatives can be found in other crops already elaborated. These are hairy caterpillar *Eupterote mollifera*, fruit fly *Gitona distigma*, bark caterpillar *Indarbela quadrinotata*, stem borer *Indarbela tetraonis*, borer *Diaxenopsis apomecynoides*, unknown leaf miner, the aphid *Aphis craccivora*, white fly *Bemisia*, scale insects *Diaspidotus* sp. and *Ceroplastodes cajani*, and spider mites. In addition cattle, sheep, pigs, and goats will eat Moringa seedlings, pods and leaves. Protect moringa seedlings from livestock by installing fence or by planting a hedge around the plot.

Pests

Termites

Termites can be a problem, first when seeds are planted, and secondly when saplings are transplanted into holes 30 cm deep and packed with decomposed manure. Though palatable to termites, moringa seems to tolerate termite damage, particularly when grown from cuttings.

Leafworm Noorda blitealis

The larvae are an important defoliator and represent the greatest threat as a pest in Niger as well as Sudan. It is only a pest of trees in the plant family Moringaceae and from time to time can become very abundant; in such cases spray spinosad or neem seed extract.

Damping off fungi, Diplodia root rot

Both of these fungal diseases occur in wet and waterlogged soils, causing severe wilting of seedlings and death of saplings.

Moringa			
Pest	Damage	Available Control Measures	Pesticides
Termites (Termites)	Feed on sown-seed and the germinating seedling as well as roots of older seedlings.	-Deep plowingOverseedingCrop rotationUse adequate fertilizers and add good quantities of decomposed manureHeap ashes around the base of seedlings and in the planting hole for the sapling.	Imidacloprid seed treatment or soil drench with a sprayable formulation. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.

			Application of neem oil in the termites
			holes.
Leafworm/	Larvae defoliate the		Tebufenozide or
Moringa green worm (Pyrale	tree		neem seed extract.
défoliatrice)			Farmers can
			contract the
			government to
			spray ULV (ultra low
			volume) products
			to large outbreaks:
			lambda cyhalothrin.
Diplodia root	Wilting of seedlings	-Provide field drainage.	Mancozeb.
rot	and death of saplings	-Make ridges or mounds to plant the	
(Pourriture des racines)		seedlings.	
Damping off	Attack seedlings	-Clean seed.	Fluopicolide
fungi	causing them to wilt	-Plant on ridges.	or fosetyl-
(Fonte des	and die	-Wide spacing.	aluminum.
semis)		-Avoid water stress by planting early.	
			Seed treatment:
			thiamethoxam,
			mefenoxam,
			and difenoconazole.
			Seed treatment:
			mancozeb
			or thiram.

APPLE OF THE SAHEL

Ziziphus mauritiana is one of the crops that will be planted in the bio-reclamation of degraded lands project. The soil surface is first scarified to break down the surface crust. Micro-catchments called demi-lunes in the Sahel are built to store run-off water for each plant. Following a rainstorm the deep-rooted trees planted in the demi-lunes use this stored water for a long period of time until the following rainstorm. Demi-lunes are planted with the apple of the Sahel which is particularly resistant to drought. The apple of the Sahel produces tasty fruit with ten times the concentration of Vitamin C as compared with apple. It is also rich in iron, calcium and phosphorus and in essential amino acids. Miscellaneous pests have been recorded in other countries: leafeating caterpillar and the green slug caterpillar, a gall-forming mite, and a small caterpillar, Meridarches scyrodes, that bores into the fruit. Diseases are powdery mildew, brown rot, and cercospora leaf spot, and leaf rust caused by Phakopsora zizyphivulgaris. The most serious pests appear to be termites and fruit flies.

Pests

Termites

Please see discussion in the moringa and groundnuts sections.

Fruit fly Carpomya incompleta

The greatest enemies of the jujube are fruit flies. Some cultivars are more susceptible than others, the flies preferring the largest, sweetest fruits, 100% of which may be attacked while on a neighboring tree, bearing a smaller, less-sweet type, only 2% of the crop may be damaged. The larvae pupate in the soil. For more information, see discussion under cucurbits.

Apple of the Sahel			
Insect pest	Damage	Available Control Measures	Ppesticides
Termites (Termites)	Feed on sown-seed and the germinating seedling as well as roots of older seedlings.	-Deep plowingOverseedingCrop rotation.	Imidacloprid seed treatment or soil drench with a sprayable formulation. Seed treatment: thiamethoxam, mefenoxam, and difenoconazole.
Fruit fly (Mouche des fruits)	Distorted young fruits with drilled spot brown that softens and sinks. Inside there are maggots.	-Cover developing fruit with paperBury damaged fruitPlant attractant plant Euphorbia blucalliShallow poughingUse yellow sticky or pheromone traps.	Naturalyte fruit fly bait and spinosad.

HIBISCUS

Hibiscus is also suited for planting in bio-reclaimed lands. *Hibiscus sabdariffa* probably originates from Africa, where it may have been domesticated in Sudan about 6000 years ago, first for its seed and later for leaf and calyx production.

Disease

Root/collar rot Phythophthora sp.

Diseased trees are most likely to be found in heavy, wet soils or sections of the orchard where water collects or is slow to drain. The Phytophthora fungi persist in the soil mainly as dormant resting spores. A tree's ability to resist infection is reduced when saturated soil conditions deprive its roots of oxygen.

Hibiscus			
Pest	Damage	Available Control Measures	Pesticides
Root/collar rot (Pourriture de la racine/du		-Grafting onto resistant root stockAmend soil with compostDigging drainage ditches.	Azoxystrobin as a soil drench.
collet)		-Avoid over-watering.-Place drip irrigation spigots away from tree trunks.	Fluopicolide or fosetyl-aluminium.

LIVESTOCK

Goat/Sheep

The main sedentary farmers are the Hausa, Kanuri, and Songhai, whereas the Fulani and Tuareg are principally nomadic and semi-nomadic pastoralists. Livestock keeping is now mostly limited to the northern part of Niger and the precarious situation in the north favors two kinds of livestock: camels and small ruminants (goats and sheep). Domestic animals are widespread and many agro-pastoral farmers in the south keep livestock as an insurance against the quirks of nature and the economy. The area of cultivated land is increasing among sedentary farmers and competes severely with livestock keeping even among sedentary farmers. Women mainly tend goats and sheep. Nigerien livestock production is based on extensive grazing but climatic vagaries, the extent and quality of pastures, and economic constraints set limits to its performance.

Although livestock is kept for food and milk, a very important sector of livestock marketing is hides, skins and leather, especially from goats. Goat milk compares favorably in nutritive value with cow's milk. Sheep were first used for mutton, skins, milk and wool. Goats thrive on grazing, browsing, or scavenging, and appear to relish grasses as well as shrubs and bushes. Historically, domestic goats were generally kept in herds that wandered on hills or other grazing areas, often tended by goat herders who were frequently adolescents, similar to the more widely known shepherd. These methods of herding are still used today. In Africa as in the Mideast, goats are typically run in flocks with sheep. This maximizes the production per acre, as goats and sheep prefer different food plants. Sheep have a cleft in their upper lip, with which they are able to pick the preferred leaves off of the plant and are very selective in their grazing habits.

Common external sheep and goat parasites include ticks, lice, and mites. The way goats are reared and the environmental conditions determine the presence or survival of a particular species of ectoparasite. The result is unthrifty, poor-performing sheep and goats. Permanent ectoparasites are passed on by infested stray or purchased sheep, borrowed rams, contact with infested sheep (at markets, common grazing, or gatherings), infested housing, and human contact (eg, contractors, shearers, vets, etc.) carrying parasites from farm to farm. External parasites limit production in sheep and goats in many ways, and result in poor quality products and economic loss. Attachment to the host causes irritation of the skin with subsequent ulceration and secondary infections, sometimes on sensitive areas of skin (teats, vagina, eyes, etc.). They feed on body tissue such as blood, skin, and hair. Heavy infestations are associated with anemia (adult female ticks can, for example, suck up to 10 ml of blood). They cause discomfort and annoyance leading to weight loss. Reduction in milk production may occur as a result of nervousness and improper nutrition because animals spend less time eating. Furthermore, external parasites can transmit diseases, some with fatal consequences, from sick to healthy animals due to their habit of moving from one host to another. Tick attachment between the claws of the feet may cause severe lameness. They cause huge economic losses through skin damage rendering it unsuitable for the leather industry.

Poultry

Poultry production plays a prominent role in the everyday meat supply for Nigeriens. Family poultry are important as provider of eggs and meat. In one study in the Department of Dakoro, in 78% of the farms, men were in charge of the poultry flocks. The main species raised were chickens (78%) and guinea fowls (18%). Millet grains and/or bran were used as feed by 99% of farmers for their poultry. Rudimentary poultry houses based on stem grass were reported. Poultry veterinary products were used in 25% of the farms surveyed, along with human medicines (21%) and traditional practices (16%). The major causes of mortality were undiagnosed diseases (72%), poor housing (13%), predation (8%), and lack of feed (6%). Own consumption (46%) was the main destination for poultry products followed by sales (43%) and donations (11%). It is generally assumed

that family poultry production systems are economically efficient because, although the output from the individual bird is low, the inputs are usually lower. A study, however, concluded that the output and technical efficiency of the family poultry production can be increased by the use of more feed, capital, medicine/vaccine, and adoption of more innovations.

The soft ticks are also a big problem for poultry, but as far as literature has indicated, do not seem to take a big part in transfer of diseases generally in livestock.

PESTS

Ticks

Pigeon tick Argas reflectus

The occurrence of ticks in Africa is one of the major limiting factors to livestock productivity. Ticks not only sucks blood thereby generally weakening their hosts if they are many enough - they also act as major disease carriers between various species of animals. When occurring in numbers, they can actually kill, especially young livestock by sucking alone. There are over 13 different tick families and more than 650 different kinds of ticks in Africa.

A. reflexus (Acari: Argasidae), the well-known pigeon tick, is the most important ectoparasite of sheep, goats, and poultry but also can involve human health. Soft ticks are usually fairly small (rarely above 5mm long) and their body is flat and their backs do not have the hard-back shield that the hard ticks have. The mouthparts are ventrally located and are covered by the front margin of the body, so they are not visible from above. The females feed at intervals, increasing their body weight by up to three times, then laying globular, dark brown shiny eggs in batches of 20 - 50. The larvae feed on the hosts for six to eleven days although chickens are the principal host, bird species may also be fed upon. Humans may also be bitten. The ticks feed at night and hide by day. They are commonly found in attics and rooms adjacent to areas where pigeons roost.

The life cycle and feeding pattern of the soft ticks are different from those of the hard ticks. The *Argasidae* are multi-host ticks with several nymphal stages, and the adults also feed repeatedly. Feeding can last from a few minutes to hours, or even days for the larvae of some species. In between feeding ticks spend the rest of their time in crevices and cracks. Most soft ticks live in nests or burrows, where they mate, although there are exceptions. Mated females take small, repeated blood meals to support the production of small batches of eggs. The occurrence of several nymphal instars and frequent adult blood meals contributes to an unusually long life span (several years) and high resistance to starvation. Some ticks can live on the ground for up to 300 days without feeding. In areas where many ticks exist, re-infection of the host occurs continuously and treatment, therefore, must be repeated regularly. In sub-humid areas the period of highest tick activity is the wet season and only few ticks are found on animals during the dry season. In lowland areas most ticks are active throughout the year and must be controlled continuously.

Ticks cause anemia, weight loss, decreased egg production, general weakness, serious illness and even death in chickens. Furthermore, they can cause paralysis and can also transmit a disease called spirochaetosis, which is a gut condition that leads to diarrhea. To monitor suspect ticks, fetch a chicken several hours after dark and examine the skin closely in a good light. When filled with blood after their nightly meal, they're large enough to see easily.

Lice

Linognathus africanus (sheep, goats), L. ovillus (sheep), L. pedalis (sheep), L. steropis (sheep, goats), Damalinia caprae (goat), Chicken body louse Menacanthus stramineus (goats, poultry), Goniodes gigas (poultry), Lipeurus caponis (poultry), Menopon gallinae (poultry), Chelopistes meleagrides (poultry): Lice are wingless insect with mouthparts adapted for piercing skin and sucking blood. Lice may survive in warm environments for 25 days in the absence of host sheep. Infestations are greatest in winter months. Lice, unlike ticks, have a marked degree of host specificity, even sheep and goats having their own distinct species. Lice are between 1 to 4mm long depending on the type of louse. They can be found crawling on the bird at the base of the feathers but are fast moving so soon move out of the light when feathers are parted. They spread from bird to bird by direct contact and clumps of eggs. Off the bird lice can survive for a few days so although less likely, can also spread from bird to bird via the hen house or litter. The life cycle is simple and usually occurs entierly on the host: four 'nymphal' stages before reaching a stage of adult sexual maturity. The generation from egg to egg is brief - 14-21 days under optimum conditions.

There are two types of lice:

- -The Biting lice graze on epidermal tissue, hair and other organic waste. They cause intense itching by their action
- -The Sucking lice have a narrow head with mouthparts adapted for penetrating the skin of the host and sucking blood. Both immature and adult stages suck the blood or feed on the skin.

There are potentially six lice species in Niger that infest goats and sheep, and five species on poultry. These records come from Nigeria. Four are in the genus *Linognathus* or sucking lice. *D. caprae* also was found on goats. In sheep, *L. ovillus* and *L. africanus* inhabit the face, *L. pedalis* inhabits the legs and feet where no wool exists. Diagnostic characteristics are the presence of nits (eggs) on wool and adult lice on skin. The chicken body louse *Menacanthus stramineus* is the most commonly found on poultry but also feeds on goats. *Menopon gallinae* and four other species can be found on poultry.

Most chickens will have a few lice on them from time to time and won't be particularly bothered by them but it's important not to let the numbers get out of control or they will be causing severe irritation and feather loss as they over groom, trying to rid themselves of them.

Heavily louse infested animals can show severe rubbing hair loss and skin thickening, scaly dry skin, and their overall health is generally poor. Wool growth and body weight are reduced, and there is a significant drop in egg production. In heavy infestations, particularly of sucking lice the animal can become anemic due to the amount of blood being taken. Lice eggs (nits) are laid in masses and stick to the base of feathers. Lice are of minor importance in the transmission of disease.

All lice species have basically the same biology and habits and the same control strategies control them:

- Nits are very hard to remove, although with care and a little warm soapy water, they can sometimes be broken off with the fingernails bit-by-bit.
- If there are a lot of nits, it is often easier to wait for them to hatch and kill the lice by using a powder approved for dusting on hens or by using drops of Ivermectin on the back of the neck under the guidance of a Vet which is detailed below under 'Treating Lice'.

Lice are easily overlooked because of their small size. When examining birds for lice, one should examine the whole body. The white egg masses at the base of the feathers are the best indicators of a lice infestation.

Goat/Sheep				
Pest	Damage	Available Control Measures	Pesticides	
Louse (Pou)	Feed on blood, hair, skin to reduce thriftiness.	-Reduce contact with carriers.	Direct treatment of animal: zeta-cypermethrin dust is dispersed over the back of the animal. Premises spray: permethrin, or tetrachlorvinphos. Spray the stall	
Tick (Tique)	Attachment causes itching, removal of blood produces anemia and reduce thriftiness.	-If tick numbers are not large, do not use acaricides. Use a needle or thorn to kill them. -Reduce contact with carriers.	and bedding area, as well as walls. Same as above.	

Poultry				
Pest	Damage	Available control measures	Pesticides	
Louse (Pou)	Feed on blood, hair, skin to reduce thriftiness.	-Provide adequate dusting areas for chickens to care for their own skin and feathers naturally. A dust bath is the chicken equivalent of a daily dirt shower and keeps control of parasitesClean, wash and disinfect cages/houses. Remove droppings regularly, once a day if possible. Remove dead birds as soon as possibleChickens should preferably be kept on concrete floorsInspect the birds regularly for mites, ticks, or fleas.	Permethrin.	
Tick (Tique)	Attachment causes itching, removal of blood produces anemia and reduce thriftiness.	-Same as aboveIf tick numbers are not large, do not use acaricides; use a needle or thorn to kill them.	Permethrin.	

ANNEX 2: FUMIGATION MANAGEMENT PLAN5



USAID Food Assistance Program Name:

PHOSPHINE FUMIGATION MANAGEMENT PLAN (FMP) (SHEETED STACKS ONLY)

THIS FMP TEMPLATE PROVIDES A STEP BY STEP PROCESS TO ENSURE SAFE AND EFFECTIVE FUMIGATION AND TRAIN FUMIGATION PERSONNEL

CONTENTS

COMMODITY AND OWNERSHIP
EMERGENCY PLANNING AND SAFETY
EQUIPMENT AND SUPPLIES
APPLICATION AND MONITORING
DISPOSAL AND CLEANUP
ANNEXED LOGS AND DOCUMENTATION

http://www.usaidgems.org/Documents/FumigationPEA/Phosphide_FumigMangmtPlan_August%202014.docx.

⁵ Downloadable at:

COMMODITY AND OWNERSHIP

PLANNED FUMIGATION DATES:	

A. OVERALL PROGRAM & CONTACT INFORMATION		
Lead Awardee		
Program Name		
Fumigation Compliance Lead		
Compliance Lead Contact Information		

ATTENTION:

To ensure full safety and efficacy, completion of this FMP is mandatory for each fumigation event.*

*Some information may remain the same across fumigation events.

B. FACILITY INFORMATION	C. FUMIGATOR INFORMATION
Name of Facility	Lead Fumigator
Location	Organization
Responsible Manager (Name, Organization & Title)	Contact Information
Contact Information	Certification # & Expiry Date (if any)

D. COMMODITY 1	O BE FUMIGATED	E. FUMIGANT PRODUCT INFO & DOSAGE	
Commodity(ies) & Amount in tons		E1. Fumigant (product name/description)	
(est) (e.g. maize 200mt)		E2. Ambient Temp (Expected indoor temp range)	
Owner of commodity		E3. Quantity Req'd	
How commodity is packaged		E4. Required time @ concentration* (e.g. 7 days @ 200ppm)	
# of stacks & size (e.g., 4 stacks 3m X 2m X 2m)		E5. Planned downtime* (Days + hours, includes aeration.)	
Last fumigation	Enter date if known. Otherwise, enter "unknown"	*REQUIRED: DOCUMENT CALCULATIONS E3, E4 & E5	
Condition	Moldy? Visibly infested?	IN ANNEX #A. NOTE THAT EFFECTIVE PHOSPHINE FUMIGATION TYPICALLY	
Moisture %		REQUIRES 7-10 DAYS	
Purpose of Fumigation			

EMERGENCY PLANNING AND SAFETY

F. CONTACT INFORMATION: MEDICAL FACILITY, EMERGENCY RESPONSE AUTHORITIES		
	LOCATION	TELEPHONE

Police			
Fire Service			
Clinic/Hospital			
Other Local Authority (specify Port Authority, District Council, Chieftaincy, etc.)			
Pesticide Regulatory Authority			
Chief of Party (or commodity point of contact)			
G1. ADVANCE NOTIFICATION PLAN FOR ABUTTERS Specify the procedures for notifying those living and working within 100m of the facility. The fumigation team needs to alert relevant entities, particularly households, about fumigation activities.			
	N PLAN FOR LOCAL AUTHORITIES ifying local authorities, as required or		

H. EMERGENCY RESPONSE PLAN
Describe the procedure to be followed if phosphine concentrations exceed (1) 0.3ppm (or local TLV, if
more stringent), or (2) 1 ppm (or local STEL, if more stringent) (TLV= threshold limit value; STEL = short
term exposure limit. See PEA Annex T-9).

I. FUMIGATION PLAN & EXCLUSION ZON	E		
REQUIRED ACTION:	Y	N	CONFIRMING INITIALS
I1. Obtain plot or make scale sketch map of facility and surroundings. (note grid paper is provided as final page of this template)			
I2. Mark locations of stacks to be fumigated.			
I3. On plot, mark exclusion zone that maintains at least a 6M perimeter from stacks to be fumigated, and which INCLUDES buildings or rooms with walls common to the room in which the stack is being fumigated. An exception must be requested if the exclusion zone cannot be maintained.			
I4. Determine if a watchman or watchmen will be required to maintain the exclusion zone. If yes, inform the facility manager immediately.			
I5. On plot, mark shut-off points for electricity, water, gas, if any.			
I6. On plot mark doors/gates to be secured to enforce exclusion zone and locations of warning signs to be posted.			
17. On plot, mark locations of hazard monitoring (at least 3 locations just outside exclusion zone, where gas is mostly likely to accumulate).			
18. On plot, mark locations of phosphine trays and monitoring lines.			
I9. Attach plot to this Fumigation Management Plan as Annex #F			

J. COMMUNICATION AND TRAINING					
REQUIRED ACTIONS	Υ	N	CONFIRMING INITIALS		
J1. Fumigation team reviews product label , MSDS, and applicator/product manual. Lead applicator provides detailed verbal briefing if required.					
J2. Lead applicator briefs the team regarding the symptoms of phosphine poisoning and first aid. (See Fumigation PEA Annex T-10)					
J3. Lead applicator briefs the team regarding the planned fumigation process with reference to the site plot (I10) WITH FACILITY MANAGER PRESENT					
J4. Lead applicator briefs the team & facility manager on EMERGENCY RESPONSE PLAN (H1) & roles and responsibilities for implementing the plan are agreed.					
J5. All employees engaged in fumigation instructed on the use, impact, and mitigation measures of phosphine fumigation.					

EQUIPMENT AND SUPPLIES

K. NUMBER OF SHEETS, SAND SNAKES AND TRAYS REQUIRED								
REQUIRED ACTION:	QUANTITY REQUIRED							
K1. Determine number of fumigation sheets required (note that joining sheets requires a 1(one) meter overlap, tightly rolled & then clipped or weighted. If clips are used, they must be applied every 20cm.) (Indicate number & size of sheets, standard 18meterX12meter sheets preferred)								
K2. Determine length of sand snakes required (double rows must be used) (in meters)								
K3. Determine number of phosphine tablet trays required								

L. CONDITION, QUANTITY & ADEQUACY OF EQUIPMENT & SUPPLIES FUMIGATION MAY NOT PROCEED UNLESS ALL ANSWERS ARE "YES" Υ **CONFIRMING INITIALS CONFIRM THAT:** L1. Required quantity of sheets (K1) meeting specifications (M1) are available L2. Required length of sand snakes (K2) are available L3. Required number of tablet trays (K3) are available L4. Respiratory equipment and protective gear meeting specifications (M2) are available FOR THE FULL TEAM and all personnel can achieve a complete face seal. No one enters the fumigation area without protective gear. L5. (1) Dry, clean cotton gloves in good condition; (2) rubber boots; (3) liquid-tight coveralls are available FOR THE FULL TEAM L6. **Detection (monitoring) equipment** meeting specifications (M3) is available to monitor HAZARD L7. Detection (monitoring) equipment meeting specifications (M3) is available to monitor EFFICACY L8. Warning signs (placards) IN APPROPRIATE LANGUAGES and WITH APPROPRIATE PICTOGRAMS and compliant with host country regulations (if any) are available in quantity required by plot (16)

M. SPECIFICATIONS FOR SHEETS, RESPIRATORY & DETECTION EQUIPMENT							
M1. FUMIGATION SHEETS	M2. RESPIRATORY PROTECTION						
 Sheets must be: resistant to ultraviolet light tear-resistant along BOTH length and width 	Properly maintained canister-type full facemask respirator . The canister must (1) be rated to protect against phosphine, (2) not expired, (3) not damaged, and (4) canisters previously used must not be opened more than 6 months ago & not have exceeded their rated time-in-use. OR						

L9. Required quantity of fumigant (E3) is available

- of material impermeable to phosphine (gas loss must be less than 1 mg/day/m2
- in good condition with ALL holes and tears mended with materialspecific adhesive and patch.
- light enough to carry (200-250g/m2) a full standard-size (18mX12m) sheet

250-micron (0.25mm) thickness PVC sheet, PVC on a nylon or terylene scrim, or multi-layer thin-film laminates are all acceptable.

Thin coatings on widely woven materials and annealed polypropylene sheets NOT acceptable.

Properly maintained self-contained breathing apparatus.(SCBA)

Other varieties of respiratory protection may be acceptable, see PEA Annex T-9.NOTE. Canister/cartridge type respirators are NOT adequate to enter a fumigation enclosure (e.g. go into a sheeted container)

M3. MONITORING EQUIPMENT

All equipment must be properly **calibrated and maintained**. Detector tubes, if used, must NOT be expired.
Efficacy monitoring equipment must be able to read in the 200-500ppm + range. Hazard monitoring equipment must be able to accurately read in over the 0.3-3ppm + range.

See PEA Annex T-9 for more information

Required Action: Complete log of all Respiratory and Detection Equipment. DESCRIPTION e.g., Canister Respirator MANUF & MODEL # KNOWN) SERIAL NUMBER KNOWN)

APPLICATION AND MONITORING

O. SUITABILITY OF FACILITY, STACKS AND TEAM FOR FUMIGATION

BY FOLLOWING THESE STEPS, MANADATORY FUMIGATION WILL BE SAFE AND EFFECTIVE.

FUMIGATION MAY NOT PROCEED UNLESS ALL CRITERIA ARE MET.

	CRITERIO	ON IS			
MANDATORY STEPS. CONFIRM THAT:	MET	NOT MET	CONFIRMING		
O1. Commodities being fumigated are not required for use before the end of the planned down time (E5) + 1 day					
O2. Expected temperature during the fumigation period will be 15°C or above.					
O3. Stacks are NOT built around pillars or against walls, and that there is sufficient clearance (1m) around each stack to effectively sheet and seal.					
O4. Surface issues : EITHER (1) the floor under <u>and for 1 (one) meter around stack</u> is crack-free concrete OR (2) the stack is placed on top of intact fumigation tarps. (If multiple tarps are used, they must be joined by tightly rolling a 1m overlap & weighting or clipping the join).					
O5. The marked exclusion zone (see I3) can be maintained for the duration of the fumigation (7-10 days or more). (Exclusion = no people EXCEPT for fumigation personnel with proper breathing equipment in this zone.)					
O6. A <u>trained</u> 2-person (or larger) team is available for application of fumigant and aeration and the team holds any required country licenses.					
O7. If watchmen are required to maintain the exclusion zone, they will be available over the entirety of the fumigation period, including aeration time.					
O8. The warehouse contains only the commodity to be fumigated.					

P. WARNING SIGNAGE AND SECURITY				
REQUIRED ACTIONS	Υ	N	CONFIRMING INITIALS	
P1. <u>Notify Abutters</u> per Notification Plan (G1). In particular, ensure that nearby residents have been informed of activity,				
P2. <u>Notify Workers</u> and any others with customary access to the exclusion zone. Brief on emergency response plan (H1)				
P3. If applicable, execute Local Authorities Notification Plan (G2)*				
P4. Post <u>warning signage</u> at all points indicated by fumigation plot (I6)				
P5. Assure that doors are ready to be locked. (Locks and keys available)				
P6. Assure that watchmen are on-site, if required to maintain the exclusion zone.				

Q. PLACING SHEETING AND COVERING STACKS				
REQUIRED ACTIONS IN EXACTLY THIS ORDER	Υ	N	CONFIRMING INITIALS	
Q1. Position sheets. Carry, do not drag the sheets into position				
Q2. <u>Cover stacks.</u> Unfold the sheets towards the stack. Place the sheet over the stack and position with 1 (one) meter of sheet lying on the ground. Unroll the sheet to cover the entire stack. If more than one sheet is used, join the sheets. Joins require a 1(one) m overlap, tightly rolled, and then clipped every 20cm or weighted.				
Q3. <u>Set sand snakes.</u> Smooth out any wrinkles and folds in sheets, and then place two rows of sand snakes on the sheets along the				

sides of the stack. Ensure that a good seal is achieved along the whole length and take special care at the corners.		
Q4. <u>Place monitoring lines.</u> Place two monitoring lines from the top and one from the bottom of each stack for efficacy monitoring. Cut small holes to insert tubes and seal holes in gas sheets with tape. Gas monitoring lines should extend outside of the exclusion area. Place duct tape over the free tube ends, except when measuring gas concentrations. Tubes MAY NOT be located near placement positions for phosphine tablets.		

R. APPLYING FUMIGANT

ATTENTION: PHOSPHINE GAS BEGINS FORMING AS SOON AS THE AIR-TIGHT PACKAGING OF PHOSPHIDE PELLETS/TABLETS IS OPENED. IT IS A DEADLY POISON. IT IS FLAMMABLE. CONTACT OF PHOSPHIDE WITH WATER WILL CAUSE FIRE OR EXPLOSION. SMELL IS <u>NOT</u> A RELIABLE INDICATOR OF DANGER.

REQUIRED ACTIONS IN EXACTLY THIS ORDER	Υ	N	CONFIRMING INITIALS
R1. Watchmen go on duty (if required to maintain the exclusion zone) & remain OUTSIDE the zone until aeration is complete (W9)			
R2. Verify ONLY personnel involved in fumigation are in the exclusion zone			
R3. Turn off electric lights & any sources of sparks			
R4. Ensure that all fumigation personnel are wearing PPE, <u>including</u> <u>respirators</u> , as per L4 & L5			
R5. Lay out the trays for aluminum phosphide tablets/pellets around the stack. Remove the sand snakes that hold down the sheets next to the trays.			
R6. Distribute UNOPENED tablets/sachets next to the trays			
R7. Position tablets/pellets in a single layer on each tray. To avoid fire risk, do not pile tablets or pellets. Slide trays under the sheets and replace the sand snakes. To minimize worker exposure to gas being released, placement of trays should be completed within 15 minutes. Work from the back of the stack towards the exit doors. Pellets may NOT touch bagged commodities.			

R8. Assure all opened tablets/pellets are used		
R9. Leave the warehouse and lock ALL doors		

S. MONITOR GAS CONCENTRATIONS FOR EFFICACY AND HAZARD & LOG RESULTS				
REQUIRED ACTIONS	Υ	N	CONFIRMING INITIALS	
S1. <u>Hazard Monitoring</u> . 1 hour, 2 hours, 4 hours & 24 hours after applying fumigant, and every 24 hours thereafter, monitor for hazard at all points designated on the fumigation plot (I7). Record results on attached log (#D).				
S2. <u>Hazard Monitoring Response.</u> If concentrations exceed 0.3ppm (or the local TLV,* if more stringent), assure that individuals move through the area only in passing. If concentrations exceed 1.0ppm (or the local STEL, if more stringent) evacuate the area. NOTE ANY SUCH ACTIONS IN EXCEPTIONS LOG (#C).				
S3. <u>Efficacy Monitoring:</u> Monitor EACH monitoring line 24 hours after fumigation application; every 24 hours thereafter. Monitor within stacks to confirm it was an effective fumigation application. Record results in attached logsheet (#E). NOTE ANY EXCEPTIONS IN LOG.				
S4. Efficacy Monitoring Response. If concentration does not reach or falls below 200ppm before additional fumigant may be added IF SCBA apparatus are used. NOTE ANY SUCH ACTIONS IN EXCEPTIONS LOG (#C).				

T. CERTIFY FUMIGATION COMPLETE OR ABORTED										
REQUIRED: CERTIFY WHICH OF THE FOLLOWING APPLIES.	√	REQ'D TIME @ CONCENTRATION e.g. 200 ppm @ 7 days								
T1. Efficacy monitoring results show that the required phosphine gas concentration was sustained over the required period in each stack										
T2. Efficacy monitoring results show that the required concentration was NOT sustained over the required period in one or more stacks.		(Copy from E4)								

U. AERATE			
REQUIRED ACTIONS IN EXACTLY THIS ORDER	Υ	N	CONFIRMING INITIALS
U1. Fumigation team puts on respirators and other PPE per L4 and L5 before entering exclusion zone.			
U2. Open all doors and ventilators. Turn on fans, if any.			
U3. Remove sand snakes from the corners of up to 2 stacks so that sheet covering each can be lifted. (If the stacks are large			

relative to the size of the room, ONLY 1 stack can be opened at a time.)		
U4. Pull the free corner of each sheet up to the top of the stack with a rope. Team leaves exclusion zone immediately.		
U5. Allow gas to leave stack and warehouse for a half-day to 1 day		
U6. Repeat U1, U4 & U5 until remaining stacks are opened		
U7. Repeat U1. Then completely remove all sheets covering stacks.		
U8. Monitor inside warehouse and directly next to stack until phosphine gas concentration is less than 0.3 ppm (or local TLV value, if more stringent.)		
U9. ONLY AFTER CONCENTRATION IS LESS than 0.3 ppm (or local TLV value, if more stringent), lead fumigator informs facility manager that the area is safe to enter.		

DISPOSAL AND CLEANUP

V. ALUMINUM PHOSPHIDE RESIDUE REMOVAL & DISPOSAL

ATTENTION: Residues contain 3-5% unreacted materials and are hazardous to breathe and touch!

ATTENTION: NEVER DISPOSE OF UNUSED TABLETS/PELLETS WITH THESE METHODS. NEVER PLACE UNUSED PELLETS/TABLETS IN A DRUM WITH OR WITHOUT DETERGENT AS A FIRE OR EXPLOSION MAY OCCUR.

REQUIRED ACTIONS	Υ	N	CONFIRMING INITIALS
V1. Personnel involved put on respirators and other PPE per L4 & L5.			
V2. Collect residue from trays in bucket or drum. Do <u>not</u> allow any residue to touch food commodity			
V3. Remove residue to a safe outdoor area			
V4. Remove warning signs & stand down watchmen			
V5. Standing upwind to avoid any evolved phosphine, mix residue slowly into soapy water, assuring the residue is fully reacted.			
V6. After any reaction is complete, dispose of mixture in a 0.5m deep disposal pit, at least 100m away from warehouse structures. Fill in hole.			

W. CLEAN-UP							
ATTENTION: Dead animals should be considered a biohazard & must be disposed as soon as possible after aeration is complete							
REQUIRED ACTIONS	Υ	N	CONFIRMING INITIALS				

W1. Crush empty phosphide tablet/pellets containers and dispose per host country requirements. If none, bury.		
W2. Inspect entire warehouse with flashlight, including under pallets and under-roof area for dead rodents and birds		
W3. Collect all dead animals wearing disposable gloves (if available). If not available, pick up with shovel or inside-out plastic bag.		
W4. Dispose of carcasses by (1) burying, wrapped in newspaper or plastic bag 0.6-1.2m deep and at least 60m from any shallow well or surface water; OR (2) burning, where it will not cause a public nuisance and in accordance with local laws; or (3) otherwise in accordance with local laws.		
W5. Wash hands thoroughly with soap.		

ANNEXED LOGS AND DOCUMENTATION

#A. DOCUMENTATION OF DOSAGE CALCULATION

Document the calculations/information used to determine the quantity of fumigant required and the "time @ concentration" efficacy threshold (e.g. 200 ppm @ 7 days)

General recommendation is 3 ALP tablets/metric ton but will vary with commodity, temperature & moisture content. 6 tablets/metric ton may be needed for highly sorptive commodities such as paddy rice, brown rice & pulses. Consult product label.

#B. FUMIGATION TIME LOG	
#B1. Planned down time (days + hrs) (from H5)	
#B2. Fumigant Applied (<i>Date & Time</i>)	
#B3. Efficacy Reached (<i>Day & Time that H4 is achieved</i>)	
#B4. Aeration Start (<i>Date & Time</i>)	
#B5. All-Clear Given (see V9) (Date & Time)	

#C. ISSUES, INCIDENTS AND EXCEPTIONS LOG

Log here any issues, incidents or exceptions that arise during the fumigation, including but not limited to phosphine concentrations > TLV outside the exclusion zone, violations of the exclusion zone, known or

suspected problems with PPE discovered after the initial inspection, members of the fumigation team who become ill, addition of fumigant to reach or sustain required concentrations, etc.													
#D. PHOSPH	IINE CC	ONCENT	TRATIO	N LOG:	HAZAI	RD MON	NITORII	NG					
Per S1, log pl	nosphir	ne gas co	oncentr	ations to	aken at	designa	ted loca	ations o	utside tl	ne exclu	sion are	ea, in pp	m.
LOCATION*	MONI.	TORING	TIME (TIME 0 :	= APPLI	CATION	OF FUN	MIGANT)				
	1 hr	2 hr	4 hr	24 hr	1 day	2 days	3 days	4 days	5 days	6 days	7 days	8 days	9 days
А													
В													

С							

^{*}As designated on plot map, Annex #F. Add locations as needed.

#E. PHOSPHINE CONCENTRATION LOG: EFFICACY MONITORING Per S3, log phosphine gas concentrations taken from monitoring lines, in ppm. MONITORING MONITORING TIME (TIME 0 = APPLICATION OF FUMIGANT) LINE* 2 days 3 days 4 days 5 days 6 days 7 days 8 days 9 days 10 days 1 2 days 3 days 4 days 5 days 6 days 7 days 8 days 9 days 10 days

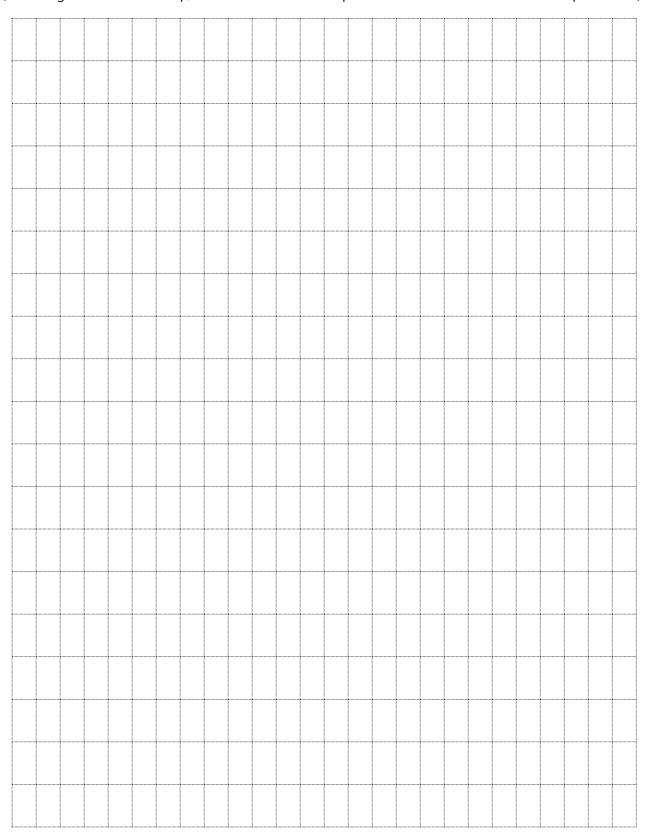
3

4

^{*}As designated on plot map, Annex #F. Add lines as needed.

#F. SCALE MAP/PLOT OF FACILITY AND SURROUNDINGS, SHOWING EXCLUSION ZONE

(use this grid for a sketch map, if a more formal site map is not available. See section I for requirements)



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ANNEX 3: FUMIGATION SAFER USE ACTION PLAN & COMPLIANCE TRACKER

Insert USAID Food Assistance Program Name

Fumigation Safer Use Action Plan & Compliance Tracker

This is an integral part of the PERSUAP and must be submitted annually with Environmental Status Report (ESR).

PROGRAM & CONT	ACT INFORMATION	DATE OF ANNUAL REPORTING SUBMISSION:			
Awardee		Annual Update #1			
Program Name		Annual Update #2			
Fumigation Compliance Lead	Name and title	Annual Update #3			
Contact Information	Email & telephone	Annual Update #4			

FUMIGATION	FUMIGATION LOG (record all fumigation events since the last annual update)										
Dates	Location (Town or City)	Warehouse Type			Commodity & Quantity Fumigated	Key Exceptions/Incidents per FMP log.					
	(P*	S*	T*							

P=Primary, S=Secondary, T=Tertiary

REQUIRED COMPLIANCE MEASURES	ACTIONS PLANNED TO ACHIEVE & MAINTAIN COMPLIANCE	STATUS OF COMPLIANCE ACTIONS
	(w/ deadlines & responsible party)	(for instance text)
Good Housekeeping IPM Measures. Fully implement the daily/weekly warehouse and commodities inspection checklist (Fumigation PEA Annex T-5) and take maintenance/corrective actions specified. NOTE: compliance with this checklist implements a set of IPM measures that are essential complements to fumigation.	(insert extra rows if needed	
Fumigation Management Plan. A fumigation management plan (FMP) will be implemented for each fumigation event. The FMP and the actual fumigation process will substantively conform to the plan provided as Annex T-3 to the Fumigation PEA, EXCEPT for changes specified below and/ or subsequently approved by the DCHA BEO. Each completed plan shall be retained for 2 years.	(insert extra rows if needed	

Complementary Use of Contact Pesticides will (1)		
be limited to the pesticide(s) authorized by this		
PERSUAP and substantively conform to contact		
pesticide best practices as set out in Fumigation	(insert extra rows if needed	
PEA Annex T-6, EXCEPT for changes specified below		
and/or subsequently approved by the DCHA BEO.		
Storage and Transport of Aluminum Phosphide		
and Contact Pesticides, if under program		
control, substantively conform to contact pesticide		
best practices as set out in Fumigation PEA Annex		
T-6, EXCEPT for changes specified below and/or		
subsequently approved by the DCHA BEO.	(insert extra rows if needed	
When Using a 3 rd -Party Fumigation Service		
Provider:		
The provided model RFQ and contract (or		
substantive equivalent) will be used to procure		
fumigation services and proposals/quotes will be	(insert extra rows if needed	
evaluated based on ability to comply with specified		
safer use practices.		
Monitoring and Corrective Action. Program will		
actively monitor compliance with above-listed		
conditions and undertake corrective actions as		
needed.	(insert extra rows if needed)	
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REQUESTED EXCEPTIONS AND CHANGES TO SPECIFIED MANAGEMENT PRACTICES

Enter here specific requested exceptions or changes to fumigation practices as per template Fumigation Management Plan provided by the Fumigation PEA Annex T-3 or storage, transport, and contact pesticide practices per Annex T-6. Reference by number & provide justification in each case. Alternately, a strike-through edit of the FMP may be submitted.
(add lines as necessary)

ANNEX 4: PHOTOS



Departmental DGPV pesticide store, Guidan Roumji.



Hand-held and backpack ULV formulation applicators. *Credit:*



FFS organic vs chemical fertilizer test-plots (potato), Gangara, Aguie. *Credit:*



Sawki program, Maradi warehouse.



Farmers and their children carrying water for vegetable irrigations, Guidan Roumji. *Credit:*



Farmer showing example of extensive aphid damage to cabbage crop, Droum, Zinder. *Credit:*



Farmer showing repackaged unidentified pesticide, Droum, Zinder. *Credit:*



Women's producer group, Guidan Sori.

Credit:



Dry-season vegetable production and simple irrigation source, Droum, Zinder. *Credit:*



Program-built well, Gangara, Aguie. *Credit:*



Water conservation and intercropping in dry-season vegetable production. *Credit:*



Farmer showing unregistered product purchased from travelling vendor from Nigeria. *Credit:*

ANNEX 5: CSP REGISTERED AND AUTHORIZED PRODUCTS AS OF NOV. 2014

Partial list of CSP authorized pesticides as of November 2014 taken from the Niger Réseau National des Chambres d'Agriculture (below). Purple indicates that the pesticide is approved for vegetable crops and blue indicates that the product has been found available in Niger. The complete CSP list of resgisterd pesticides from November 2014 can be viewed at the link provided just below. There are a total of 295 products approved by the CSP as of November 2014.

Liste partielle des pesticides autorisés par le CSP / Novembre 2014 – Sélection réalisée par le RECA

La seule liste officielle est disponible sur le site du CSP: http://www.insah.org/doc/pdf/liste_globale_pesticides_autorises_par_CSP_Nov_2014.pdf
La liste globale comprend 295 produits.

La liste partielle proposée par le RECA comprend les pesticides (insecticides, acaricides et fongicides) homologués pour les cultures maraîchères (en couleur), le coton, les arbres fruitiers et autres cultures.

Elle ne comprend pas les produits pour le traitement des semences et la lutte antiacridienne.

N°	Nom commercial	OMS	Firme	Matière(s) active(s)	Domaine d'utilisation
2	ACARIUS	II	Savana	lahamectine (TX g/I)	Insecticide / Acaricide autorisé contre les insectes et les acariens en cultures maraichères
16	ALMECTINE 20 EC	II	ALM International	emamectine benzoate (20 g/l)	Insecticide autorisé contre les ravageurs du cotonnier
18	AMSAC 150 SC	II	Savana	nnaayacarn (150 g/H	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
20	ANTRACOL 70 WP		BAYER CROP Science AG	INTAINIDEN LALLO/KOT	Fongicide autorisé contre l'alternaria, la rouille, l'oïdium, la fusariose de la tomate
23	ATTAKAN C 344 SE	II		, , ,	Insecticide autorisé contre les chenilles phyllophages, carpophages et les pucerons du cotonnier

24	AVAUNT 150 EC STEWARD 150 EC	III	DuPont	indoxacarb (150 g/l)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
25	AVAUNT 150 SC	III	DuPont	indoxacarb (150 g/l)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
26	AZOX	III	Savana	azoxystrobine (250 g/l)	Fongicide semi-systémique autorisé contre la pyriculariose foliaire et paniculaire en culture de riz
30	BATIK WG	III	Arysta LifeScience	Bacillus thuringiensis (32.000 Ul/mg)	Insecticide autorisé contre les chenilles du chou
32	BELUGA 480 SC	II	Arysta LifeScience	diflubenzuron (480 g/l)	Insecticide autorisé contre les chenilles carpophages et phyllophages du cotonnier
33	BENEVIA 100 OD	III	DuPont	cyantraniliprole (100 g/l)	Insecticide autorisé contre les ravageurs du cotonnier
34	BENEVIA 100 OD	III	DuPont	cyantraniliprole (100 g/l)	Insecticide autorisé contre les ravageurs du cotonnier à la dose de 0,4 l/ha
36	BOMEC 18 EC	II	SCPA SIVEX International (SSI)	abamectine (18 g/l)	Insecticide/Acaricide autorisé sur cultures maraichères (Tomate)
38	CAIMAN B19	II	SCPA SIVEX International (SSI)	emamectine benzoate (19,2 g/l)	Insecticide des cultures cotonnières contre les chenilles carpophages et phyllophages, les insectes piqueurs suceurs
39	CALFOS 500 EC	II	Arysta LifeScience	profenofos (500 g/l)	Insecticide autorisé contre les chenilles phyllophages, carpophages, les piqueurs suceurs et les acariens du cotonnier
40	CALIFE 500 EC	II	Savana	profénofos (500 g/l)	Insecticide autorisé contre les chenilles phyllophages et carpophages du cotonnier
41	CALLIFAN EXTRA	II	Arysta LifeScience	acétamipride (32 g/l) / bifentrine (120 g/l)	Insecticide autorisé contre les insectes piqueurs suceurs et ravageurs du cotonnier

51	CAPT 88 EC	II	ALM International	acétamipride (16 g/l) / cyperméthrine (72 g/l)	Insecticide contre les chenilles et les piqueurs- suceurs du cotonnier
52	CAPT 88 EC	II	ALM International	acétamipride (16 g/l) / cyperméthrine (72 g/l)	Însecticide autorisé sur le Haricot
53	CAPT 96 EC	II	ALM International	acétamipride (24 g/l) / cyperméthrine (72 g/l)	Insecticide autorisé contre les insectes et les mouches blanches
54	COBRA 120 EC	II	Arysta LifeScience	(36 g/1)	Insecticide autorisé contre les chenilles phyllophages et carpophages et contre les insectes piqueurs-suceurs du cotonnier
56	COGA 80 WP	III	Savana	mancozeb (800 g/kg)	Fongicide de contact à large spectre pour les cultures maraichères, fruitières, vivrières et florales
60	CONQUEST C 88 EC	II	Arysta LifeScience	acétamipride (8 g/l) / cyperméthrine (80 g/l)	Insecticide autorisé contre les chenilles phyllophages, carpophages et les pucerons du cotonnier
61	CONQUEST C 176 EC	II	Arysta LifeScience	acétamipride (32 g/l) / cyperméthrine (144 g/l)	Insecticide autorisé contre les chenilles phyllophages, carpophages et les acariens du cotonnier
62	CORAGEN 20 SC	IV	ALM International		Insecticide autorisé contre les chenilles phyllophages et coprophages et contre les insectes piqueurs-suceurs
66	CROTALE	II	ArystaLifeScience	acetamipride (16g/l) indoxacarbe (30g/l)	Insecticide contre les chenilles, carpophages (Helicoverpa, Earias, Diparopsis), phyllophages (Spodoptera, Cosmiphila) et les insectes piqueurs suceurs du cotonnier

67	CURACRON 500 EC	III	Syngenta		Insecticide / acaricide autorisé contre les principales espèces phyllophages et carpophages et les acariens du cotonnier
70	CYPRA 100 EC	II	Rivale	Cypermetrine (100 g/1)	Insecticide autorisé contre les larves de Helicoverpa armigera et les mouches blanches
71	CYPERANET 88 EC	II	DTE	19CAL9MINTIGE LIN G/LI/	Insecticide autorisé contre les chenilles phyllophages et carpophages du cotonnier
72	CYPERCAL P 230 EC	II	Arysta LifeScience	levnerméthrine (30 g/l) / proténetes	Insecticide/acaricide autorisé contre les chenilles phyllophages, carpophages et les acariens du cotonnier
73	CYPERCAL P 690 EC	II	Arysta LifeScience	cyperméthrine (90 g/l) / profénofos (600 g/l)	Insecticide autorisé contre les chenilles phyllophages, carpophages et les insectes piqueurs-suceurs du cotonnier
74	CYPERCAL P 720 EC	II	Arysta LifeScience	CV/Dermeinrine (1 /11 G/11 /	Insecticide /acaricide autorisé contre les principaux insectes carpophages et phyllophages du cotonnier et contre les acariens
75	CYPERCAL 50 EC	III	Arysta LifeScience	cyperméthrine (50 g/l)	Insecticide autorisé contre les insectes ravageurs de la tomate
76	CYPERPRONET 690 EC	II	DTE PDA		Insecticide autorisé contre les ravageurs des agrumes, du caféier, du cotonnier, et des cultures maraîchères
78	DECIS 25 EC	II	BAYER CROP Science AG	deltamethrine (25 g/l)	Insecticides contre les ravageurs de la tomate

81	DELTACAL 12,5 EC	II	Arysta LifeScience		Insecticide autorisé contre les chenilles Helicoverpa armigera hubner et les mouches blanches de la tomate
82	DOYEN 62	III	SCPA Sivex International (SSI)		Insecticide contre les chenilles, carpophages et les insectes piqueurs suceurs de la tomate
83	DENIM FIT 50 WG MATCH FIT 50 WG	III	Syngenta	/ Inferitron (400 g/kg)	Insecticide autorisé contre les principaux ravageurs du cotonnier ainsi que contre les insectes résistants aux organophosphorés
85	DJIGIKAN 800 EC FINISH 360 SL	III	ALM International	malarnion (XUU 0/1)	Insecticide autorisé contre les chenilles phyllophages et carpophages du cotonnier
91	DITHANE M 45	III	Dow Agro Sciences	mancozeb (800 g/kg)	Fongicide à large spectre autorisé contre les maladies des cultures maraichères
93	DURSBAN 4 EC	II	Dow Agro Sciences		Insecticide autorisé contre les ravageurs des arbres fruitiers, du caféier, du cotonnier, et des cultures maraîchères
95	DURSBAN 5 G	III	Dow Agro Sciences		Insecticide autorisé contre les termites, les fourmis, les noctuelles, les taupins, les vers blancs sur maïs et sorgho
99	EFORIA 045 ZC	II	Syngenta	IIIIIameinoxam (50 0/11 / Iamnoa-	Insecticide autorisé contre les insectes piqueurs suceurs, les phyllophages et carpophages du cotonnier

100	EMA 19,2 EC	II	ADAMA MAKHTESHIM LTD.	emamectine benzoate (19,2 g/l)	Insecticide autorisé pour le contrôle des ravageurs du cotonnier
101	EMA SUPER 56 DC	II	ADAMA MAKHTESHIM LTD.	emamectine benzoate (24 g/l) / acétamipride (32 g/l)	Insecticide pour le traitement des champs de cotonniers contre les ravageurs phyllophages et carpophages
102	EMACOT 019 EC	II	Savana	emamectine benzoate (19 g/l)	Insecticide autorisé contre les insectes phyllophages, carpophages et les piqueurs suceurs du cotonnier
103	EMACOT 050 WG	II	Savana	emamectine benzoate (50 g/kg)	Insecticide autorisé contre les chenilles carpophages et phyllophages du cotonnier
104	EMAPYR	III		emamectine benzoate (20 g/l)pyriproxyfene (60 g/l)	Insecticide autorisé contre les ravageurs du cotonnier
105	EMARON	III		emamectine benzoate (20 g/l) /lufenuron (80 g/l)	Insecticide autorisé contre les ravageurs du cotonnier
106	EMIR 88 EC	II		cyperméthrine (72 g/l) / acétamipride (16 g/l)	Insecticide autorisé contre les chenilles et les insectes piqueurs
107	EMIR FORT 104 EC	II	Savana	acétamipride (72 g/l) / cyperméthrine (32 g/l)	Insecticide contre les chenilles et les insectes piqueurs-suceurs du cotonnier

108	ENGEO 247 SC ALIKA 247 SC	II	Syngenta	Hambda_cvnalothrine (IIIb d/I) /	Insecticide systémique binaire autorisé contre les insectes piqueurs suceurs, des phyllophages et des carpophages en culture du cotonnier
110	FANGA 500 EC	II	ALM International	inrotenotos (SUII o/I)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
133	GOLDEN BLUE 985 SG		SCPA SIVEX International (SSI)	sulfate de cuivre pentahydraté (985 g/kg)	Fongicide autorisé contre l'anthracnose du manguier
150	IDEFIX	II	Savana	hydroxyde de cuivre (65,6%)	Fongicide bactéricide autorisé pour les cultures maraîchères et fruitières
156	JUMPER 75 WG	U	SCPA Sivex International(SSI)		Fongicide autorisé dans la lutte contre les maladies fongiques (alternariose, phytophthora infestans, septorise) en culture de tomate
159	KART 500 SP		SCPA SIVEX International (SSI)		Insecticide autorisé contre les insectes ravageurs du chou
164	K-OPTIMAL		SCPA SIVEX International (SSI)	ampda_cvnalothrine \cdot \cdot \cdot \cdot \cdot	Insecticide autorisé contre les insectes ravageurs du chou et du cotonnier
166	KOPHOS 500 EC	II	ETS Amadou Baïba Kouma	profénofos (500 g/l)	Insecticide/Acaricide contre les ravageurs du cotonnier

170	LAMANET 46 EC	II	DTE	lambda-cyhalothrine (30 g/l) / acétamipride (16 g/l)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
171	LAMBDACAL P 636 EC	II	Arysta LifeScience	lambda-cyhalothrine (36 g/l) / profénofos (600 g/l)	Insecticide autorisé contre les chenilles phyllophages, carpophages et les insectes piqueurs-suceurs du cotonnier
172	LAMBDACAL P 212 EC	II	Arysta LifeScience	lambda-cyhalothrine (12 g/l) / profénofos (200 g/l)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
173	LAMBDACAL P 648 EC	II	Arysta LifeScience	profénofos (600 g/l) / lambda- cyhalothrine (48 g/l)	Insecticide autorisé contre les chenilles carpophages et phyllophages du cotonnier
174	LAMBDALM 50 EC	II	ALM International	lambda-cyhalothrine (50g/l)	Insecticide autorisé contre les insectes de la tomate et du haricot vert
175	LAMPRIDE 46 EC	II	Senchim	lambda-cyhalothrine (30 g/l) / acétamipride (16 g/l)	Insecticide autorisé contre les chenilles phyllophages, carpophages et les insectes piqueurs suceurs du cotonnier
176	LASER 480 SC	III	Dow AgroSciences	spinosad (480 g/l)	Insecticide utilisé dans la lutte contre les insectes nuisibles du chou.
189	MARIGOLD	U	Arysta LifeScience	thyme oil (5,52 g/l) / tagetes oil (5,52 g/l)	Insecticide autorisé contre la mouche blanche de la tomate

190	МЕТНОАТЕ 40 ЕС	II	Rivale	dimethoate (40 g/l)	Insecticides autorisé contre les larves de Helicoverpa armigera et les mouches blanches des cultures maraîchères
192	MOVENTO PLUS	III	Bayer CropScience AG	imidaclopride (120 g/l) spirotetramat (120 g/l)	Insecticide systémique autorisé contre les piqueurs suceurs du cotonnier
194	MORAN 30 DF	U	SCPA SIVEX International (SSI)	indoxacarbe (300 g/kg)	Insecticide contre les chenilles phyllophages et carpophages du cotonnier
195	NATIVO 300 SC	III		tébuconazole (200 g/l) trifloxystrobine (100 g/l)	Fongicide contre l'alternaria, la rouille, l'oïdium, la fusariose sur l'arachide
199	NOMAX 150 SC	III		alpha-cyperméthrine (75 g/l)/ téflubenzuron (75 g/l)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
200	NOMOLT 150 SC	III	BASF SE	téflubenzuron (150 g/l)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
201	NOVAC 116 SC	II	ADAMA	novaluron (100 g/l) /	Insecticide pour le contrôle des ravageurs du
			MAKHTESHIM LTD.	acétamipride (16 g/l)	cotonnier

205	OPTIMAL SUPER	III	SCPA SIVEX International (SSI)	indovacarne (/3 d/II / acetaminride	Insecticide autorisé contre les principaux ravageurs des cultures cotonnières
206	ORTIVA 250 SC	III	SYNGENTA	1970 V V STronin (/ 511 or / 1)	Fongicide systémique utilisé contre les maladies cryptogamiques foliaires et du fruit de la tomate.
207	ORTIVA TOP	III	SYNGENTA	PAZON VSTROMIN I ZURI OZIT	Fongicide systémique utilisé contre les maladies cryptogamiques foliaires et du fruit de la tomate.
210	PACHA 25 EC	II	Savana	amhda_cvhalothrine(5 g/11/	Insecticide autorisé contre les chenilles, les mouches blanches et les pucerons des cultures maraichères
219	PYRIFORCE 480 EC	II	SCPASIVEX International	chiornyrinnos etnyi (480 g/l)	Insecticide contre la cochenille farineuse du manguier
220	PIRIPRO 100 EC	III	SCPA SIVEX International (SSI)	invrince vangene i illil (7/1)	Insecticide larvicide et ovicide autorisé pour la protection des cultures cotonnières
221	PROFENET 500 EC	II	DTE	inrotenotos (SUII g/I)	Insecticide autorisé contre les insectes phyllophages et carpophages du cotonnier
224	PYRICAL 5 G	U	Arysta LifeScience	chlorpyrifos-éthyl (50 g/kg)	Insecticide autorisé contre les insectes du sol

226	PYRICAL 480 EC	II	Arysta LifeScience	chlorpyrifos-éthyl (480 g/l)	Insecticide autorisé contre les chenilles d'Helicoverpa sur tomate
227	PYRICAL 480 EC	II	Arysta LifeScience	chlorpyrifos-éthyl (480 g/l)	Insecticide non systémique autorisé contre la cochenille farineuse du manguier (Rastrococcus invadens)
232	PYRIBAN 480 EC	II	Rivale	chlorpyrifos-éthyl (480 g/l)	Insecticide autorisé contre les larves de Helicoverpa armigera et les mouches blanches des cultures maraîchères
233	PYRINEXQUICK 424 EC			deltamethrine (24 g/l) / chlorpyrifos-éthyl (400 g/l)	Insecticide-Acaricide autorisé contre les chenilles phyllophages, carpophages et les acariens du cotonnier
234	PYRINEXQUICK 212	II	ADAMA	deltaméthrine (12 g/l) /	Insecticide / acaricide autorisé contre les chenilles
	EC		MAKHTESHIM LTD.	chlorpyrifos-éthyl (200 g/l)	phyllophages, carpophages et les acariens du cotonnier
240	RELDAN 40 EC	III	Dow AgroSciences	chlorpyrifos-méthyl (400 g/l)	Insecticide autorisé contre les insectes des cultures vivrières et maraichères
249	SAVANEM	II	Savana	ethoprophos (200 g/l)	Insecticide nématicide autorisé pour le traitement du sol

251	SAVAHALER WP	II	SCPA SIVEX	methomyl (250 g/kg)	Insecticide autorisé pour la protection des cultures maraîchères contre les attaques de noctuelles défoliatrices, insectes broyeurs et insectes piqueurs suceurs (œufs et larves)
265	SUCCES APPÄT 0,24 CB	III	DOW AgroScience	spinosad (0,24 g/l)	Insecticide pour le contrôle des mouches de fruits sur le manguier
266	SUNEEM 1% EC	III	SENCHIM	azadirachtine (10 g/l)	Insecticide autorisé contre les insectes ravageurs du cotonnier
267	SYSTHANE 240 EC	III	Dow Agro Sciences	myclobutanil (240 g/l)	Fongicide autorisé contre les maladies des cultures maraichères
270	SUNHALOTHRIN 2,5% EC	III	WYNCA SUNSHINE	lambda-cyhalothrine (25 g/l)	Insecticide non systémique de contact autorisé pour lutter contre Helicoverpa, les pucerons et les mouches blanches en culture de tomate
271	SUNPYRIFOS 48% EC	III	WYNCA SUNSHINE	chlorpyriphos –éthyl (48 g/l)	Insecticides non systémique de contact autorisé pour lutter contre Helicoverpa, les pucerons et les mouches blanches en culture de tomate
273	TAMEGA	II	Savana	deltamethrine (25 g/l)	Insecticide autorisé contre les larves de Helicoverpa armigera et sur les mouches blanches en culture de tomate et de poivron
274	TENOR 500 EC	II	Senchim	profenofos (500 g/l)	Insecticide autorisé contre les chenilles phyllophages et carpophages du cotonnier

278	THUNDER 145 O- TEQ SOLOMON 145 0 - TEQ	II	Bayer CropScience	imidaclopride (100 g/l) / betacyfluthrine (45 g/l)	Insecticide systémique autorisé pour le contrôle des chenilles et les insectes piqueurs suceurs de la tomate
279	TIHAN 175 O TEQ MOVENTO TOTAL 175 O-TEQ	III	BAYER CROP Science AG	flubendiamide (100 g/l) /spirotetramate (75 g/l)	Insecticide contre les ravageurs du cotonnier
280	TIHAN 175 O TEQ MOVENTO TOTAL 175 O-TEQ	III	Bayer CropScience	spirotetramate (75 g/l) / flubendiamide (100 g/l)	Insecticide systémique autorisé pour le contrôle des chenilles et les insectes piqueurs suceurs de la tomate
281	TIMAYE	II	SCPA SIVEX International (SSI)	deltaméthrine (0,6 g/kg)	Insecticide avec un attractif, autorisé contre les mouches de fruits
282	TITAN 25 EC	II	Arysta Life Science	acétamipride (25 g/l)	Insecticide autorisé contre les insectes piqueurs- suceurs des cultures maraîchères
287	VERTIMEC 18 EC	II	Syngenta	abamectine (18 g/l)	Insecticide / Acaricide autorisé contre les parasites des cultures fruitières et légumières
289	VIPER 46 EC	II	Arysta LifeScience	indoxacarbe (30 g/l) / acétamipride (16 g/l)	Insecticide autorisé contre les lépidoptères et autres insectes piqueurs-suceurs de la tomate
290	VYTAL 310 SL	Ib	Arysta LifeScience	oxamyl (310 g/l)	Nématicide autorisé en culture de canne à sucre

[•] Les produits avec la ligne en couleur sont homologués pour des cultures maraîchères.

• Les produits avec le numéro (première colonne) en bleu sont en vente ou ont été trouvés en vente au Niger.

• Classification OMS

L'Organisation mondiale de la santé (OMS) classe **la toxicité aiguë des pesticides** en se référant aux doses létales (DL50) orale et cutanée, lesquelles peuvent varier selon que le produit se présente sous une forme solide ou liquide.

- Les pesticides de **classe Ia** sont extrêmement toxiques,
- ceux de classe Ib sont hautement toxiques,
- ceux de **classe II** sont modérément toxiques,
- alors que les pesticides de classe III sont peu toxiques.
- Le **symbole** U indique les pesticides pour lesquels un risque aigu est peu probable lors d'un usage normal.

La dose létale 50 cutanée est un indice du degré de toxicité aiguë d'une matière active ou d'un produit commercial. Cette valeur exprime la dose cutanée qui est mortelle pour 50 % d'un groupe expérimental d'organismes exposés.

La dose létale 50 orale est un indice du degré de toxicité aiguë d'une matière active ou d'un produit commercial. Cette valeur exprime la dose ingérée qui est mortelle pour 50 % d'un groupe expérimental d'organismes exposés

ANNEX 6: KEY REFERENCES

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